THE OHIO JOURNAL OF SCIENCE

VOL. XLV JULY, 1945 No. 4

THE EFFECT OF CHEMICAL SOIL TREATMENTS ON THE DEVELOPMENT OF WHEAT MOSAIC

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INTRODUCTION

Wheat mosaic virus, *Marmor tritici* H.[2], is unique in the fact that it is transmitted from one generation of wheat to another through the soil. Both winter and spring wheat are susceptible to infection when planted in the fall, but usually the symptoms are not noticeable until the following spring when the plants make rapid growth. In a previous communication (4) the writer reported results on the study of certain insects and nematodes with regard to their ability to act as virus vectors. Neither the insects nor nematodes considered transmitted the virus. Thus far the vector of wheat mosaic virus occurring east of the Mississippi River has not been found, and the method of inoculation when plants are grown in virus-infested soil is open to conjecture.

It is known that a soil treatment with a solution of formaldehyde in water will control wheat mosaic, as will steam sterilization (5). It also has been shown (3) that control of the disease can be obtained by heating infested soil at a temperature of 60° C. for ten minutes.

From our general knowledge of the disease it is believed that a soil-borne organism is responsible for transmission of the virus. In an attempt to elucidate this point a study was made to determine what effect certain chemicals used as insecticides and nematocides would have on the development of the disease when applied to virus-infested soil. The present paper discusses some of the results obtained.

MATERIAL AND METHODS

The soil used in these tests was collected from localities in Indiana where mosaic had seriously affected wheat over a period of many years. When treated, the soil was at a moisture content of 25 per cent and gave a pH reading of 4.8. By analysis the soil contained 25 per cent clay, 59 per cent silt, and 16 per cent sand and fine gravel.

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[1]This work was conducted while the writer held the Muellhaupt Scholarship, Department of Botany, Ohio State University, Columbus, Ohio. Grateful acknowledgement is made to Dr. R. M. Caldwell of Purdue University, and Dr. Benjamin Koehler of the University of Illinois, who supplied the soil for investigational purposes. Without their aid this study could not have been undertaken. The writer is also indebted to Dr. E. N. Transeau, Dr. W. G. Stover, and Dr. C. C. Allison, of Ohio State University, for their assistance in the preparation of the manuscript. Paper from the Department of Botany, the Ohio State University, No. 478.

[2]The Latin name of the virus follows the system of nomenclature in the Handbook of Phytopathogenic Viruses (2).

Eighteen air-tight metal containers, with a capacity of 490 cubic inches, were filled to one inch from the top with virus-infested soil which previously had been passed through a screen of one-fourth-inch mesh. Six chemicals were studied at different concentrations. Calcium cyanide (granulated) was used at 1, 3, and 5 gms.; carbon disulphide at 2, 5, and 10 cc.; while chloropicrin, ethyl chloride, ethylene dichloride and methyl bromide each were used at 0.3, 1, and 3 cc. Each sample of chemical was placed in one of the metal containers, approximately equidistant from the bottom and the surface of the soil; then water was sprinkled over the surface to create a partial seal. A close-fitting, cardboard disc, which previously had been given three coats of animal glue on each side, was next inserted over the soil; and glue was used as a seal between the disc and container. This procedure was followed since the work of Godfrey (1) showed that the gases of chloropicrin and carbon disulphide do not readily diffuse through membranes of animal glue. As a check on the effect of the chemicals on the development of the plants, non-infested soil was treated in the manner described above, except that only six containers were used, one for each of the six chemicals. In each case the check soil was treated with a dosage equal to the largest amount of chemical applied to the infested soil.

At the beginning of the experiment all soil was at a temperature of 16° C., and after the containers were sealed they were placed in a greenhouse where the temperature was approximately 27° C. After seven days the discs were removed and the soil from each can spread out on separate paper sheets and placed outdoors to facilitate aeration. Strong odors of carbon disulphide, calcium cyanide, chloropicrin, and methyl bromide could easily be detected as the discs were removed from their respective containers.

The wheat was sown in No. 10 tin cans. The bottoms of the cans were perforated with holes to permit drainage of excess water. The required number of these cans were first half filled with composted soil known to be free from virus. To this was added a three-inch thick layer of the chemically treated soil in which the wheat was planted four days after the discs were removed. The treated soil from each container was placed in five of the tin cans and fifteen seeds of Purdue No. 1 wheat, a variety highly susceptible to mosaic, were planted in each can. This method has been shown by Webb (7) and confirmed by the writer to give about as much infection as when infested soil was used exclusively without the underlying non-infested soil.

After the wheat was planted all cans were placed outdoors over winter in soil trenches about eight inches deep and each series of five cans was placed in one row. There was a space of four inches between the cans in each row and sixteen inches between each row of five cans. As a control, wheat was also planted in virus-infested and non-infested soil which had not been treated with the chemicals. The outside soil was firmly pressed around each can and drainage of surface water was cared for by providing ditches in order that the soil within the cans should not become mixed.

EXPERIMENTAL RESULTS

There was a good stand of wheat and the plants were approximately six inches tall when the hard frosts and snows of winter settled. Considerable heaving of the soil within the cans caused some plants to die. No counts of plants were made in the fall, but one record from fifty cans selected at random made in the spring when the plants were making rapid growth gave an average of between eight and nine plants in each can. The diseased and healthy plants were not counted separately, but were critically examined three times up to the period when the wheat was in the boot stage. The results were recorded in a general way as: complete control; incomplete when both healthy and diseased plants were present; and no control.

The examinations revealed that calcium cyanide was more effective in controlling the disease when used at the higher concentrations. At 1 gm. there was no control; at 3 gms. control was incomplete; but 5 gms. completely controlled the disease. There were no diseased plants in the soil treated with carbon disulphide at each of the concentrations of 2, 5, and 10 cc. Chloropicrin and methyl bromide were similarly effective when used at 0.3, 1, and 3 cc. At the latter concentrations ethyl chloride was not effective, and ethylene dichloride gave only incomplete control at the two higher concentrations.

In another experiment virus-infested soil, of an amount equal to that used previously, was placed in a tight container and subjected to the fumes of naphthalene at room temperature for 17 days. The soil was placed in cheesecloth bags and suspended over the naphthalene flakes. After four days of aeration it was planted to wheat in the manner described above. Another similar quantity of soil was air dried, then mixed thoroughly with 500 gms. of rotenone powder with active ingredients of 0.75 per cent. Water was then added before the wheat was sown. No disease developed as a result of either of these treatments.

The plants grown in the non-infested soil remained healthy throughout the length of the experiment, while there was a very high incidence of disease in the virus-infested soil which had not been subjected to the chemicals. No evidence of any effect of these materials on the development of the plants was noticed. The results of these experiments are recorded in Table I.

TABLE I

EFFECT OF CHEMICAL TREATMENTS TO VIRUS-INFESTED SOIL ON THE DEVELOPMENT OF WHEAT MOSAIC*

CHEMICAL	AMOUNT USED	EFFECT ON DISEASE
Calcium cyanide (granulated)	1.0 gm. 3.0 gm. 5.0 gm.	No control Incomplete control Complete control
Carbon disulphide	2.0 cc. 5.0 cc. 10.0 cc.	Complete control " " " "
Chloropicrin	0.3 cc. 1.0 cc. 3.0 cc.	Complete control " " " "
Ethyl chloride	0.3 cc. 1.0 cc. 3.0 cc.	No control " " " "
Ethylene dichloride	0.3 cc. 1.0 cc. 3.0 cc.	No control Incomplete control " "
Methyl bromide	0.3 cc. 1.0 cc. 3.0 cc.	Complete control " " " "
Rotenone	500.0 gm.	Complete control
Naphthalene		Complete control

*Grateful acknowledgement is made to Innis, Speiden & Company for chloropicrin; to the Pittsburg Chemical Company for methyl bromide; and to The Dow Chemical Company for ethylene dichloride and ethyl chloride.

DISCUSSION

These experiments were not planned in order to find a means of controlling wheat mosaic as this already is accomplished in a practical way by the use of resistant varieties, but it did seem of interest to study what effect some chemicals which are toxic to certain organisms would have on the development of the disease. While these results are somewhat interesting, it must be remembered that more than one replication of this work might have yielded other data, but unfortunately not enough virus-infested soil was available for such an undertaking.

The results obtained indicate that the liquids previously used effectively as insecticides and nematocides were also effective in controlling the disease. Ethylene dichloride and ethyl chloride were not as effective, but nothing is known as to the efficiency of the animal glue membranes used as a seal over the fumigating chambers on the retention of these gases. It is interesting to point out that no disease developed in the soil with which rotenone dust had been mixed. In this case the soil had first been stored in a well ventilated room until dry before it was mixed with the rotenone, but this procedure was not considered to have affected the results obtained, since McKinney (6) has shown that the disease develops in virus infested and retained in an air-dried condition for three years.

The nature of the vector of wheat mosaic virus is still open to discussion. It is believed that a subterranean insect or nematode transmits the virus, and that the action of the materials used was on the vector rather than on the causal agent. There are many kinds of subterranean arthropods such as thrips, spring tails, garden centipedes, mites, and root aphids, to mention a few, which might pass unnoticed to the unaided eye while examining soil. However, it is somewhat unusual to expect such forms of animal life to remain dormant in air-dried soil for three years and then resume parasitic habits after this period if favorable conditions for plant growth are provided. Nematodes, on the other hand, have this capacity.

SUMMARY

A study was made on the action of certain chemicals, commonly used as insecticides and nematocides, on the development of winter wheat mosaic. Samples of a specified quantity of virus-infested soil were subjected for seven days to the gases of five volatile liquids and two solids; besides, one contact insecticide was studied in this connection.

Calcium cyanide when used in the greatest amount and carbon disulphide, chloropicrin and methyl bromide at each of the three concentrations used completely controlled wheat mosaic. Ethylene dichloride reduced the incidence of the disease at the two larger dosages, but etyhl chloride gave no control. The fumes of naphthalene and rotenone dust, when mixed with the soil, also gave complete control of the disease.

The action of these chemicals was probably on the vector rather than on the virus.

LITERATURE CITED

1. **Godfrey, G. H.** 1934. The confinement of chloropicrin and other gases for fumigation purposes. Phytopath. 24 : 1366–1373.
2. **Holmes, F. O.** 1939. Handbook of phytopathogenic viruses. Burgess Pub. Co. (Minneapolis).
3. **Johnson, Folke.** 1942. Thermal inactivation of wheat mosaic virus in soil. Science N. S. 95 : 610.
4. 1945. Epiphytology of winter wheat mosaic. Ohio Jour. Sci. 45: 85–96.
5. **McKinney H. H.** 1923. Investigations of the rosette disease of wheat and its control. Jour. Agr. Res. 23: 771–800.
6. 1937. Mosaic diseases of wheat and related cereals. U. S. Dept. Agr. Circ. 442.
7. **Webb R. W.** 1928. Further studies on the soil relationships of the mosaic disease of winter wheat. Jour. Agr. Res. 36 : 53–75.

SOME LOCATIONS FOR FOSSIL PLANTS IN OHIO

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INTRODUCTION

The object of this paper is not an intrusion on the field of the botanist but is simply the listing of places favorable for the collecting of plant fossils in Ohio and the recording of the geology of such beds so that the botanist will know the position of the stratum in the geological column. The localities are definitely recorded (by number) and the place of contact is mapped on the topographic sheets (filed with the Botany Department, Ohio State University). The work of the geologists, as here defined, extends over a period of more than one hundred years (1836–1944) hence the actual exposure may now (1944) be hidden but the rock formations are still there. Diligent search may be necessary to uncover the fossil beds.

The tools for exploration should be: topographic map of the area, hand level, 6-foot ruler to determine position of the bed, a good geologist's hammer, pick and shovel, and, in some cases, a breast auger and a few sticks of dynamite. Coal mines usually yield some plant fossils, in the roof shales, in the bony partings, in the "mother coal" bands, and in the underclays. The treatment of the horizons is, in general, in ascending order, that is, from the Sharon coal of the Pottsville Series of the Pennsylvanian system to the Hundred sandstone of the Washington formation of the Permian system.

PENNSYLVANIAN SYSTEM

Throughout the geological ages the great period for plant species was during the time of the deposition of the thick mass, over 1,100 feet in Ohio, of sediments constituting the Pennsylvanian system. Then the coal beds, mainly of organic matter, were deposited, cycle after cycle, and on the average about 35 feet apart.

Some of these beds are quite thick over extensive areas and hence took great masses of vegetable matter to form them. The underclays, purified largely through the action of organic acids, bear much evidence of plant roots and stems. The shales overlying the coal beds are locally rich in plant remains, often in a fine state of preservation. However, the coal forming stages were closed frequently by subsidence, letting in the sea with the deposition of limestones and calcareous shales with a wide range of animal fossils.

POTTSVILLE SERIES

Pottsville time evidently opened with an abundance of plant species, as is indicated by the thickness and number of coal beds and by the numerous plant markings in the overlying shales. This series of rocks in Ohio is, on the average, about 256 feet in thickness and contains twelve recognized coal beds, some of which are of major importance. These rocks extend from Scioto County on the Ohio River to Trumbull and Mahoning Counties on the Ohio-Pennsylvania line.

SHARON COAL HORIZON

The Sharon coal is found chiefly in three fields:

(a) Jackson field, in Jackson, Pike and Scioto Counties.

(b) Massillon field, in Stark, Wayne, Summit and Portage Counties.

(c) Mahoning Valley field, in Trumbull and Mahoning Counties.

In general the roof shales of the Sharon coal contain plant fossils and locally they are very rich in well preserved material.

Reference: Geological Survey Ohio Vol. 1, Paleontology, Plant Fossils by J. S. Newberry, pages 359–385.

Location: See Akron, Kent, Massillon, Warren and Youngstown sheets for old mine locations.

The plant fossils were gathered largely from Coal Hill near Tallmadge, from Mineral Ridge south of Warren, and from the Massillon field near Massillon. Although the mining of coal is small at present in these areas, yet a few mines are found. Further, some outcrop exposures are available for collecting.

Reference: Second Annual Report on the Geological Survey of Ohio, 1838, page 60.

Location: A detached hill, one mile west of the center of Tallmadge, Summit County, overlies at least 500 acres of accessible coal. Kent topographic sheet.

"The coal (Sharon) is somewhat undulating, varies in thickness from two to five feet, and cokes well. The shale and sandstone roof contains an abundance of vegetable fossils."

Reference: Section 70, field notes, Jackson County, Stout.

Location: Shaft mine of the Jackson Iron and Steel Company, west of Jackson, in the southwest corner of Section 30, Lick Township, Jackson County. Jackson topographic sheet.

	Ft.	In.
Ore, *Lincoln*	1	0
Sandstone, flaggy	42	0
Shale, gray	5	0
Coal, *Anthony*	0	6
Clay, soft, *Sciotoville*	3	0
Covered	63	0
Top of shaft.		
Shales and covered	25	0
Shale, with plant fossils	5	0
Coal, *Sharon*	3	3
Shale, sandy	2	10
Conglomerate, *Sharon*	60	0

Many Sharon coal mines of the Jackson district yield plant fossils in the overlying shales. Some mines show flattened stems and trunks, a few of rather large size. As this is the oldest coal in Ohio these plants represent the life at the beginning of the great coal forming period, the Pennsylvanian system.

Reference: Section 91, field notes, Jackson County, Stout.

Location: Shaft mine of the Globe Iron Company, located one and one-fourth miles southeast of Jackson in the east central part of Section 28, Lick Township, Jackson County. Jackson topographic sheet.

		Ft.	In.
Sandstone		10	0
Ore, Kidney, *Upper Mercer*		0	6
Covered		77	0
Shales, parts covered		10	0
Coal blossom, *Vandusen*		0	4
Covered		28	0
Coal, *Bear Run*		0	8
Clay, siliceous		1	0
Shale, gray		1	0
Covered		20	0
Sandstone, massive, *Massillon*		10	0
Top of shaft.			
Shale and sandstone		100	0
Shale, gray, with many plant fossils		10	0
Coal, bony	*Sharon*	0	1
Coal, good	*Sharon*	3	3½
Coal, bony	*Sharon*	0	4

Reference: Geological Survey Ohio, Fourth Series, Bulletin 20, page 594.

Location: "Sharon conglomerate—In the sandy layers of the Sharon conglomerate in eastern Harrison and Madison townships, Scioto County, well preserved trunks and stems of Coal Measure plants were seen and in a few places observed even in the pebbly layers." "Sharon coal horizon—As would be expected, plant remains are common at this horizon, especially in the regions where the coal is well developed. Many root markings are present in the clays below the coal; while in the shales above the impressions of plant trunks and stems are common. The leaves are not usually well preserved."

SCIOTOVILLE CLAY HORIZON

The Sciotoville clay is widely distributed, but in patches across the State. The chief productive field is in eastern Scioto County. Small bodies of clay are also worked in Jackson, Vinton and Hocking Counties.

Reference: Geological Survey Ohio, Fourth Series, Bulletin 20, page 596.

Locality: largely Scioto County: "Sciotoville Clay Horizon—The clay contains impressions of roots of Coal Measure plants, but no evidence of animal life was found. The shales and shaly sandstone above the clay in many localities in Scioto and Jackson Counties contain fossil *Conostichus* and *Asterophycus* in large numbers. A few places for collecting are: the old clay mine on Daum Hill, in Section 33, Harrison Township, Scioto County; on the land of Dr. Keyes, in Section 28, Harrison Township; along the cut of the Baltimore and Ohio Southwestern Railroad, near Gephart; and on the point of the hill just north of the plant (abandoned) of the Buckeye Fire Brick and Clay Company at Scioto Furnace. At the last named locality worm tracks are also found in the shaly sandstone."

Reference: Section 1, field notes, Scioto County, Stout.

Location: Munn Hill, southwest Section 33, Harrison Township Scioto County. *Conostichus* and *Asterophycus* found in shales and shaly sandstone above the Sciotoville clay. Clay horizon marked by old strip mines near the top of the hill. Sciotoville topographic sheet.

	Ft.	In.
Pottsville formation:		
Shale and shaly sandstone, with plant fossils	20	0
Coal, *Anthony*	0	6
Clay, flint, many root impressions, *Sciotoville*	3	6
Shale and covered	38	0
Erosion interval:		
Flint, pebbles and ore, *Harrison*	2	0
Waverly formation:		
Shales and shaly sandstones.		

Such fossils are also present on the narrow ridge in the southeastern part of Section 32, along the ridge in southeastern Section 29, and along the main ridge in the southern part of Section 28, Harrison Township, Scioto County.

Reference: Section 55 L. field notes, Scioto County, Stout.

Location: Cut of Baltimore and Ohio Railroad, northeast of Gephart, in the east central part of Section 30, Bloom Township, Scioto County. Sciotoville topographic sheet.

		Ft.	In.
Shales, thin bedded, blue, with Conostichus in cut of railroad		27	0
Coal, dense, bright, good	*Anthony*	0	4
Shale, impure		0	2
Coal, dense, bright, good		0	7
Clay, flint and semiflint, good, with root impressions, *Sciotoville*		5	6
Conglomerate, *Sharon*		20	0

Reference: Section 246, field notes, Scioto County, Stout.

Location: Section at Scioto Furnace, on point of hill in southwestern Section 21, Bloom Township, Scioto County, Sciotoville topographic sheet.

	Ft.	In.
Sandstone, shaly	10	0
Shales, with thin sandstone and flag ore layers, sandstone layers with worm tracks	4	0
Covered	5	0
Shale with thin sandstone layers	6	0
Covered	16	0
Shales with thin sandstone layers, also Conostichus fossils	21	0
Coal smut, *Anthony*	0	2
Clay, flint, sandy, *Sciotoville*	10	0

Reference: Section 258, field notes, Jackson County, Stout.

Location: Up road one mile west of Riegel School, just south of crossroads, in the central part of Section 4, Hamilton Township, Jackson County. Oak Hill topographic sheet.

The Sciotoville clay very frequently, contains many root impressions, locally giving the name "Calico clay" to the material. At this place this condition prevails:

		Ft.	In.
Shales and covered		20	0
Sandstone, flaggy, red colored, very ferruginous, horizon of *Lincoln* ore		3	0
Shale, gray		3	0
Shales and covered		8	0
Sandstone, medium bedded		19	0
Covered		15	0
Sandstone		1	0
Coal, dense	*Huckleberry*	0	8
Shale, dark		1	3
Coal, dense		1	2

		Ft.	In.
Clay, dark, sandy		2	0
Clay shales		5	0
Ore, siliceous, *Guinea Fowl*		1	6
Shale, gray		1	3
Coal blossom, Anthony		0	1
Clay, very siliceous, light, root marked	*Sciotoville*	4	6
Clay, very siliceous, light	*Sciotoville*	3	0
Clay, siliceous, with ore nodules	*Sciotoville*	1	0
Sandstone, irregularly bedded, red colored		5	8

GUINEA FOWL ORE HORIZON

The Guinea Fowl ore is local in distribution and is confined largely to Scioto, Jackson, and Vinton Counties. It was worked for iron smelting only in Scioto County. Locally the shale, sandstone, and iron ore at this horizon are sparingly fossiliferous.

Reference: Section 65, field notes, Scioto County, Stout.

Location: Record taken along the road, just east of the center of Section 10, Madison Township, Scioto County, on the property of Sampson Spriggs. Sciotoville topographic sheet.

	Ft.	In.
Sandstone, many plant fossils	2	0
Ore, blocky, good, *Guinea Fowl*	0	5
Sandstone, ferruginous	0	8
Shale and covered	10	0
Clay, good, light, plastic, *Sciotoville*	2	0

QUAKERTOWN COAL HORIZON

The Quakertown coal is widely distributed across Ohio from Scioto County on the Ohio River to Mahoning County on the Ohio-Pennsylvania line. Locally it bears plant fossils, occasionally in abundance and well preserved.

Reference: Section 52, field notes, Scioto County, Stout, also Geological Survey Ohio, Fourth Series, Bulletin 20, pages 551 and 596.

Location: On land of Henry Moore, south of Frederick Creek, in the northeastern part of Section 20, Bloom Township, Scioto County. Sciotoville topographic sheet.

		Ft.	In.
Shale, with plant fossils		2	0
Shale, black, with thin coal bands	*Quakertown*	0	4
Coal, solid block, good	*Quakertown*	1	5
Shale and covered		31	0
Ore, *Guinea Fowl*		0	6
Shale		6	6
Coal, *Anthony*		0	2
Clay, flint and semi-flint, *Sciotoville*		3	0

Reference: Geological Survey Ohio, Vol. 2, Paleontology. Description of Fossil Plants from Lower Carboniferous Strata, E. B. Andrews, pages 413–426.

Location: "Plants found in a thin band of bituminous shale located a little above the base of the Coal Measures, in Perry County, about two miles east of Rushville. This layer of shale is from 25 to 30 feet above the top of the Maxville limestone. The shale containing the plants I (Andrews) have never found except at one spot, where it is exposed in a ditch by the roadside, and all the plants were found within the limits of a few square yards." The probable location of this spot is in the west central part of Section 26, Reading Township, Perry County. The horizon is the Quakertown or possibly Bear Run coal. Thornville topographic sheet.

LINCOLN OR JACKSON SAND BLOCK ORE HORIZON

This ore is very uncertain in distribution and in character. The chief field is in southern Ohio. Locally it bears plant fossils, some well preserved.

Reference: Geological Survey Ohio. Fourth series, Bulletin 20, page 597.

Location: Worked in southeastern Section 16, Bloom Township, Scioto County. Scioto-ville topographic sheet.

"Lincoln ore.—The deposits of Lincoln ore north of Scioto Furnace contain plant fossils."

Reference: Section 88, field notes, Jackson County, Stout.

Location: The largest mine of Jackson Sand Block ore was on the property of John W. Corn, in the northwestern part of Section 2, Scioto Township, Jackson County. Jackson topographic sheet.

In this area the Lincoln or Jackson Sand Block ore contains some plant fossils. Seeds and seed pods are present but not common. The deposits formerly worked were southwest of Jackson in southwestern Lick, southeastern Liberty, and northeastern Scioto Townships, Jackson County.

		Ft.	In.
Shale, blue		6	0
Ore, good	Jackson Sand Block	1	2
Shale, blue		0	11
Ore, solid block		5	10
Clay shale, sandy.			

At this place the ore lies 115 feet above the Sharon coal.

VANDUSEN COAL HORIZON

The Vandusen coal is irregularly but rather widely distributed. It is always thin, seldom reaching one foot in thickness. In southern Jackson County the overlying shales are rich in plant fossils, well preserved.

Reference: Section 266, field notes, Jackson County, Stout.

Location: Record taken along the stream on the Marion Vandusen property and along the road in the east central part of Section 1, Hamilton Township, Jackson County. Coal seen in bank of Little Scioto River. Oak Hill topographic sheet.

		Ft.	In.
Ore, *Upper Mercer*		0	6
Covered		37	0
Ore, Lower Mercer or *Little Red Block*		0	3
Covered		77	0
Shale, dark blue		7	0
Shale, light blue, with many plant fossils well preserved		2	0
Shale, bony	*Vandusen*	0	6
Coal, good		0	11

Reference: Section 285, field notes, Jackson County, Stout.

Location: Plant fossils are also abundant in the shales above the Vandusen coal along the stream in the south central part of Section 13, Scioto Township, Jackson County, on the property of W. T. Plummer and that of H. A. Wykle. Oak Hill topographic sheet.

	Ft.	In.
Ore, *Upper Mercer*	0	4
Covered	43	0
Sandstone and covered	20	0
Covered	14	0
Coal and bone shale, *Lower Mercer*	4	0
Covered	9	0
Shale, gray	11	0
Shale, blue, many plant fossils	7	0
Coal, *Vandusen*	0	11

Reference: Section 308, field notes, Jackson County, Stout.

Location: Record taken near the Grange Hall, east central Section 19, Franklin Township, Jackson County, seen along road on Four-mile Creek, near Portsmouth-Jackson Pike. Oak Hill topographic sheet.

	Ft.	In.
Shales and shaly sandstone	8	0
Shale, dark, with many plant markings	1	0
Shale, coaly, *Vandusen* coal horizon	0	5
Clay, light, shaly	1	0
Sandstone	5	0

UPPER MERCER COAL HORIZON

The mineable deposits of Upper Mercer coal are confined largely to southern Ohio, in Jackson, Scioto, and Lawrence Counties. The roof shales frequently bear plant fossils and locally are rich in such material. The chief area for collecting is north of Jefferson Furnace in Jackson County.

Reference: Section 169, field notes, Jackson County, Stout.

Location: On the property of Stephen Jones in south central Section 8, Jefferson Township, Jackson County, the Upper Mercer coal is mined for local use. The overlying shale is rich in plant fossils. Oak Hill topographic sheet.

	Ft.	In.
Sandstone and shale	17	0
Shales	8	0
Clay and clay shales, light, *Brookville*	7	0
Sandstone	8	0
Covered	6	0
Sandstone, massive	18	0
Ore, *Upper Mercer*	0	2
Shale and covered	8	10
Ore, *Sand Block*	0	4
Shale, rich in plant fossils	9	8
Coal, good, *Upper Mercer*	1	10
Clay, light	2	0
Sandstone, massive	25	0

BEDFORD COAL HORIZON

In general, the Bedford coal is overlain by the Upper Mercer limestone, flint, or ore, all of marine origin. Locally, however, these are absent and shale is found on the horizon. In a few places this shale bears plant fossils.

Reference: Section 63, field notes, Vinton County, Stout.

Location: Record taken along the road in the south central part of Section 17, Elk Township, Vinton County. Zaleski topographic sheet.

		Ft.	In.
Sandstone, soft		15	0
Coal, good	*Winters*	0	6
Clay, impure		0	3
Coal, good		0	7
Clay, dark		0	5
Coal, good		1	2
Covered, with flint		7	0
Top of road on ridge.			
Soil		4	6
Shale, gray		6	0
Shale, badly weathered, fossiliferous, *Putnam Hill*		0	6
Coal blossom, *Brookville* or *Newland*		4	0

		Ft.	In.
Clay, light, plastic		4	0
Shale, gray		13	0
Shale, dark, plant fossils, Bedford coal horizon		1	0
Clay, dark, impure		2	6
Shale, siliceous		7	0
Sandstone, soft, part shaly		6	0
Clay shale, siliceous, *Upper Mercer* coal horizon		2	0
Covered		19	0
Limestone, shaly, part covered	*Lower Mercer*	5	0
Limestone, hard, blue		0	7

TIONESTA COAL HORIZON

The Tionesta coal is widely distributed but usually thin and shaly. Its position is close below the Brookville clay. Where shale intervenes between the Tionesta coal and the Brookville clay this shale often bears plant fossils, locally in abundance.

Reference: Section 16, field notes, Muskingum County, Lamborn.

Location: Section taken at the old stone quarry near the plant of the Zanesville Stoneware Company in Putnam, a suburb of Zanesville, Muskingum County. Zanesville topographic sheet.

	Ft.	In.
Limestone, *Putnam Hill*	2	0
Clay and covered, *Brookville*	3	0
Shales, sandy	8	0
Shales, gray to dark, plant fossils abundant	9	6
Coal, *Tionesta*	1	10
Clay, siliceous	1	2
Sandstone, shaly	1	0
Sandstone, *Homewood*	21	0

Reference: Second Annual Report on the Geological Survey of Ohio, 1838, page 101, J. W. Foster.

Location: At Zanesville.

"Few places in the world, perhaps, afford plant fossils in such abundance and perfection as the mines about Zanesville. Many of the plates in the splendid work, "Histoire des Vegetaux Fossile," by M. Adolphe Brongniart, were figured from specimens furnished him by the late Ebenezer Granger, Esquire, or from drawings sent by W. A. Adams, Esquire, all of which were procured near Zanesville. Among that collection were the *Neuropteris Grangeri*, named in honor of the first gentleman; and the *Poacites lanceolata*, vegetables which have been found only at Zanesville."

Further, for the Tionesta horizon on Putnam Hill, near Zanesville see Observations on the Bituminous Coal deposit of the valley of the Ohio, and the accompanying rock strata; with notices on the fossil Organic remains and the relics of Vegetable and Animal bodies, illustrated by a Geological map, by numerous drawings of plants and shells, and by views of interesting scenery; by Dr. S. P. Hildreth, of Marietta, Ohio, the American Journal of Science, and Arts, Vol. XXIX, January, 1836, pages 30–38.

ALLEGHENY SERIES

In Ohio the Allegheny series has a thickness of close to 212 feet and in the section bears thirteen coal beds, some of which are exceptionally well developed. Plant fossils are common in many localities but only a few of the richer fields will be noted here.

CLARION COAL HORIZON

In most of the field the Clarion coal is overlain by the Vanport limestone of marine derivation. Locally this limestone is replaced by shale which occasionally bears plant fossils.

Reference: Section 53, field notes, Vinton County, Stout.

Location: On the Orval Lewis proprety, just east of Prattsville, in north central Section 26, Madison Township, Vinton County. Wilkesville topographic sheet.

	Ft.	In.
Sandstone, soft, friable	10	0
Shale, gray	12	0
Coal, shaly, *Scrub Grass*	1	5
Shale, black, carbonaceous, plant fossils	4	2
Coal, with partings, *Clarion*	4	0

Reference: Section 93, field notes, Columbiana County, Lamborn.

Location: Section along the paved road, west side of California Hollow, just north of the center of Section 24, Liverpool Township, Columbiana County. Wellsville topographic sheet.

		Ft.	In.
Sandstone, gray, siliceous		20	0
Coal, on outcrop, *Rogers, Lower Freeport*		2	0
Clay, siliceous		2	0
Shale, gray, siliceous		25	0
Sandstone and covered		50	0
Coal blossom, *Lower Kittanning, No. 5*		2	0
Clay and covered		5	0
Sandstone, shale and covered		83	0
Sandstone, heavy ledge		2	0
Shale, gray, siliceous		1	8
Sandstone		1	1
Shale, gray, siliceous, ferruginous		1	3
Shale, dark, carbonaceous, with plant fossils		0	5
Clay, gray, plastic, a little siliceous	*Clarion*	0	9
Clay, gray, very siliceous at base		1	5
Sandstone		20	0

LOWER KITTANNING COAL HORIZON

The Lower Kittanning coal is very persistent across the State, seldom being absent from the section. The overlying shales frequently yield some plant fossils but locally offer good collecting.

Reference: Section 179, Geological Survey Ohio. Report of Progress, 1870, page 179, Gallia County.

Location: Record taken in Section 7, Huntington Township, Gallia County, about 1½ miles east of Keystone Furnace. Wilkesville topographic sheet.

	Ft.	In.
Clay shale, blue, rich in coal plants	6	0
Coal, upper 8 inches shaly, *Lower Kittanning*	4	0
Covered	50	0
Ore, *Ferriferous*	1	0
Limestone, Vanport	4	0

This coal is exposed along the valley in the southwestern part of Section 7, at an elevation close to 700 feet.

Reference: Section 150, field notes, Vinton County, Stout.

Location: Section taken along the road to the ridge in the northeastern part of Section 22, Elk Township, Vinton County. (See Bulletin 31, Geol. Survey Ohio, page 294.) Zaleski topographic sheet.

		Ft.	In.
Shale, gray		5	0
Coal, bony	*Middle Kittanning* mine of Jacob Morgan, elevation 900 feet	0	6
Shale, dark		0	3
Coal, good		2	8
Shale, impure		0	1
Coal, good		0	4
Clay shale, sandstone and covered		38	0
Shale, gray, with well preserved plant fossils		5	0
Clay shale, dark, with papery coal		1	3
Coal, good	*Lower Kittanning*	0	4
Clay shale		0	4
Coal, hard, bony		2	5
Clay shale		0	4
Coal, poor		0	6
Covered		6	0
Sandstone		25	0
Covered, *Vanport* limestone in interval		6	0
Coal, rough	*Clarion*	1	0
Clay, impure		0	6
Coal, good		1	7
Clay shale		0	1
Coal, good		1	1

STRASBURG COAL HORIZON

In Ohio the Strasburg coal is only locally well defined, best in the Strasburg area of Tuscarawas County. However, the horizon may be traced over a wide area.

Reference: Section 34, field notes, Muskingum County, Stout.

Location: At the pit of the Burton-Townsend Brick Company, No. 2 plant, east of Zanesville, Muskingum County. Philo topographic sheet.

		Ft.	In.
Sand, used for molding sand		20	0
Shale, gray, used for brick		40	0
Coal, bony	*Middle Kittanning*	0	7
Coal, good		2	2
Shale, dark		0	1
Coal, good		0	10
Clay, plastic, shaly		5	6
Sandstone, ferruginous, shaly		2	6
Shale, with very fine plant fossils well preserved		4	6
Coal, hard, bony, *Strasburg*		0	2
Clay, plastic		5	0
Clay, part flint, with limestone nodules		7	0
Coal smut, *Lower Kittanning*		0	1
Clay, light, plastic		7	0
Clay, very siliceous		7	0
Sandstone.			

In the following section the shale bearing plant fossils is not well identified but evidently belongs to the Strasburg coal horizon.

Reference: Section 77, Thesis, Ohio State University, 1929, Theodore Ralph Meyers, The Geology of Jefferson and Bedford Townships, Coshocton County, page 77.

Location: Coal mine one-fourth mile northeast of McCurty School in the southeastern part of Section 19, Bedford Township, Coshocton County. Brinkhaven topographic sheet.

		Ft.	In.
Sandstone, massive, yellowish-brown, *Lower Freeport*		25	0
Shale, blue-gray		1	6
Coal, shaly	*Middle Kittanning*	0	7
Shale, dark		0	2½
Coal, good		2	7
Clay shale, gray		0	½
Coal, fair		0	3
Clay, plastic, light colored		0	4
Shale, siliceous, with plant fossils		1	6

SNOW FORK ORE HORIZON

Locally across the State and from 5 to 15 feet below the Middle Kittanning coal a limestone or an iron ore makes its appearance. In eastern Ohio in Columbiana and Mahoning Counties the limestone, the common phase, is known as the Salem and in the Hocking Valley of Athens and Hocking Counties the iron ore, there important for iron smelting, was known as the Snow Fork.

Reference: Record 600, Second Annual Report of the Geological Survey of Ohio, 1838, pp. 143–4. C. Briggs, Jr. Also Geol. Survey Ohio, Volume 111, pages 866 and 906–907, Andrews.

Location: Chief field on Snow Fork east of Buchtel, in Section 6, York Township, Athens County.

"The most continuous, and probably the most valuable, deposits of iron ore in this county (Athens), is a few feet below the Nelsonville (Middle Kittanning) coal. This is a very heavy, compact ore, of a bluish color, and varies in thickness, from 6 to 10 inches. It contains impressions of ferns and other extinct vegetation. It is well disclosed at Whittimore's (one mile east of Buchtel) on the Snow Fork of Monday Creek, resting on a bed of shale, which disintegrates into a yellowish, ochrey clay. Split in the line of cleavage, it often reveals beautiful impressions of vegetable."—Briggs.

"On lower Monday Creek, and on Snow Fork, the ore is in flat discs, which contain coal plants in a state of beautiful preservation. The ore is recognized by all familiar with the geology of this district (Hocking Valley) from its relation to Coal No. VI, (Middle Kittanning) with which it is closely associated, underlying it at an interval of two to ten feet. It is a very compact and close-grained, blue carbonate, lying in large blocks and kidneys, in the clays that support the coal. It is also characterized from the Hocking Valley to the Ohio River by holding beautifully preserved coal plants. Leaflets of ferns, bits of bark, and branches are found throughout its substance, often in an exquisite state of preservation. Insect remains are to be expected here. The ore was first recognized with all of these peculiarities by the geologists of the First Survey (1838). The locality at which they found it is one of the best known today (1878), viz., the Whitmore farm on Snow Fork, a mile east of Bessemer (Buchtel). It is designated in the section as the Snow Fork ore."—Andrews.

MIDDLE KITTANNING COAL HORIZON

The Middle Kittanning is one of the great coal beds of Ohio. It is persistent and maintains good thickness and quality across the State. In large areas in eastern and central Ohio it is overlain by shales and limestones with marine fossils. However, in the Hocking Valley around New Straitsville, Shawnee, Hemlock, and Buckingham the overlying shales provide one of the best collecting grounds for plant fossils in Ohio. Other areas in southern Ohio yield some material of fair quality.

Reference: Section 6, field notes, Jackson County, Stout.

Location: Record taken in the northeastern part of Section 4, south, Madison Township, Jackson County, on the Thomas Davis property just west of Sardis Church. Oak Hill topographic sheet.

		Ft.	In.
Shale, siliceous		5	0
Shale, very fossiliferous, plant types		2	0
Shale, "draw slate"		0	2
Coal, good	*Middle Kittanning*	1	11
Clay and bony coal	*Middle Kittanning*	0	2
Clay, siliceous		4	0

Reference: Section 841, Geological Survey Ohio, Report of Progress, 1869, page 100; Ibid, Volume 111, pages 841–842.

Location: "On the farm of Benjamin Sanders, Monroe Township, Perry County, on the west branch of Sunday Creek the coal (Middle Kittanning) measures 11 feet." This section was taken a little below Hemlock. New Lexington topographic sheet.

		Ft.	In.
Soil		..	..
Shale, with coal plants		..	..
Coal	*Middle Kittanning*	1	1
Slaty streak	*Middle Kittanning*	0	3
Coal	*Middle Kittanning*	5	9
Clay parting	*Middle Kittanning*	0	1½
Coal	*Middle Kittanning*	3	0
Fire clay		..	..

Reference: Geological Survey Ohio, Report of Progress 1869, page 99.

Location: "At Gaver's mill, and on the adjacent land at L. M. McDonald, Esquire, near the Coal Dale, P. O., Salt Lick Township, Perry County, the seam (Middle Kittanning) measures 6 feet, 2 inches. Location north of New Straitsville, not definitely placed. New Lexington topographic sheet.

		Ft.	In.
Sandstone, heavy		40	0
Shale, blue, rich in coal plants		4	6
Coal, slaty	*Middle Kittanning*	0	2
Coal, good	*Middle Kittanning*	0	8
Shale, with pyrite	*Middle Kittanning*	1	0
Coal, good	*Middle Kittanning*	2	4
Clay, black	*Middle Kittanning*	0	0½
Coal, good	*Middle Kittanning*	0	10
Clay, black	*Middle Kittanning*	0	1
Coal, good	*Middle Kittanning*	1	10½

"Here there is a good slate roof, very rich in plant fossils."

CONEMAUGH SERIES

The last invasion of the ocean during Pennsylvanian time occurred at the horizon of the Skelley limestone about midway in the Conemaugh series. Above that member the strata are entirely fresh water and below it both marine and fresh water. This group of rocks in Ohio averages about 400 feet in thickness. It bears eleven named coal beds but all of them are thin, some mere soot streaks. However, they afford good collecting for the paleo-botanist. The outstanding horizons are the Mahoning, Mason, and Harlem, each of which will yield much good material.

MAHONING COAL HORIZON

The Mahoning coal near the base of the Conemaugh group of strata is one of the outstanding horizons in Ohio for plant fossils. The coal is of importance only in the eastern part of the State. A few of the better places will be listed.

Reference: Section 318, field notes, Gallia County, Stout.

Location: Taken along road, from the valley to the ridge crest in Section 34, Morgan Township, Gallia County. Bidwell topographic sheet.

		Ft.	In.
Shale, gray		11	0
Clay shales, red		7	0
Limestone, very fossilferous, *Ames*		2	0
Shale, gray		18	0
Clay shale, red		15	0
Shale, gray		9	0
Clay shale, red		10	0
Sandstone, shaly		6	0
Covered		16	0
Limestone, *Cambridge*		2	0
Coal, *Wilgus*		1	0
Clay, light		1	0
Shales and covered		7	4
Sandstone, shaly, ferruginous		0	8
Shale, siliceous		9	0
Covered		6	0
Limestone, shaly	*Brush Creek*	1	0
Shale, calcareous		6	0
Limestone, irregular		1	0
Sandstone, calcareous, ripple marked		33	0
Coal, *Mason*		1	0
Shale, blue		15	0
Shale, very rich in plant fossils		4	0
Coal, good, *Mahoning*, on John Spires property		0	10
Clay, light		3	0
Clay, mottled		5	0
Shales, gray, calcareous		6	0
Clay shales, light, parts covered		10	0
Sandstone, massive, *Mahoning*		10	0
Coal, *Upper Freeport*, below sandstone but not seen		..	..

Reference: Section 1 C, Geological Survey Ohio, Fourth Series, Bulletin 17, Condit. Page 231.

Location: Shale pit in southeast Section 7, Center Township, Carroll County. Carrollton topographic sheet.

"The Deckman-Duty Brick Company, Carrollton.

"This brick plant is situated on the north side of the Wheeling and Lake Erie Railroad, about one mile southwest of Carrollton.

"At the hill top is a coarse-grained sandstone, 12 feet thick, which is stripped. The underlying shale, 54 feet thick, is bluish-gray in the unweathered portion, and near the surface shows greenish or rusty-brown tints. Irregular carbonaceous streaks, having abundant plant impressions, are plentiful in the lower portion, together with occasional carbonate concretions. The lower portion of the pit exposing the Mahoning coal ('Strip Vein' of Salineville) with a thickness of about 1 foot, and the Upper Freeport coal, lying 40 feet lower, is mined in a neighboring hollow."

MASON COAL

As a coal bed the Mason is of little importance in Ohio. The usual mark is a few inches of shaly coal or a mere soot streak. Locally, however, it offers good collecting for fossil plants.

Reference: Section 350, field notes, Gallia County, Stout.

Location: Section taken along the road in the northwest corner of Section 34, Raccoon Township, Gallia County, Bidwell topographic sheet.

		Ft.	In.
Shales, gray		8	0
Shale, hard, bony		0	4
Shale, many plant fossils		2	8
Coal, bony	*Mason*	0	5
Coal, good		1	2

Reference: Section 1045, Geological Survey Ohio, Fourth Series, Bulletin 35, page 125, Lamborn.

Location: Section taken at the Quarry of the General Stone Company, above the river road, in the northern part of Section 25, Island Creek Township, Jefferson County. Steubenville topographic sheet.

	Ft.	In.
Shale, arenaceous, estimated	40	0
Clay, bluish-gray, with limestone nodules	4	0
Clay shale, red	20	0
Coal blossom, *Wilgus*	0	1
Clay, gray, arenaceous	6	2
Clay shale, red, with ore nodules	18	0
Sandstone, massive, *Buffalo*	35	0
Covered	32	0
Shale, gray, calcareous	8	0
Clay, dark, shaly	1	4
Clay, grayish-brown, arenaceous	5	4
Shale, calcareous	18	8
Shale, dark, with plant impressions	1	2
Coal, shaly, *Mason*	0	3
Clay, gray, plastic	8	0

Reference: Section 964, Geological Survey Ohio, Fourth Series, Bulletin 35, pages 25 and 26, Lamborn.

Location: Section secured along Croxton Run, in the central part of Section 32, east, Knox Township, Jefferson County. Steubenville topographic sheet.

Conemaugh Series:		Ft.	In.
Limestone, greenish, fossiliferous, *Ames*		1	9
Shale, gray, arenaceous		8	0
Clay shale, red, *Round Knob*		28	2
Clay, shaly, dark, *Barton*		10	4
Clay, with nodules of limestone	*Ewing*	2	6
Limestone, nodular, fossiliferous		1	4
Sandstone, shaly, *Cow Run*		28	6
Shale, arenaceous		2	0
Shale, black, with thin coal bands		2	0
Shale and covered		46	0
Limestone, blue, arenaceous, fossiliferous, *Cambridge*		0	11
Clay shale, blue to yellow in color		14	4
Shale, black, with shaly coal, *Wilgus*		1	10
Clay, dark, arenaceous		3	0
Clay shale		23	10
Limestone, black, fossiliferous, *Brush Creek*		1	3
Shale, dark, fissile		1	10
Shale, bony		1	2
Shale, black, with many plant impressions		4	6
Coal, bony, *Mason*		0	8
Clay, dark, with iron ore nodules		5	0

Reference: Section 1,008, Geological Survey Ohio, Fourth Series, Bulletin 35, pages 108–109, Lamborn.

Location: Record taken in the south central part of Section 34, Ross Township, Jefferson County. Salineville topographic sheet.

	Ft.	In.
Sandstone and arenaceous shale	26	0
Shale, dark, fossiliferous, *Brush Creek*	17	2
Shale, dark, with many plant fossils	3	0
Clay and covered, *Mason* horizon	14	10
Limestone, impure, ferruginous	1	2
Clay, with limestone nodules	15	8
Shale, gray to pink	28	4
Coal blossom, *Mahoning*	2	6
Clay, gray, plastic	2	0
Covered	9	4
Shale, gray, arenaceous	25	10
Shale, black, and shaly coal. *Upper Freeport*	0	6
Shale and covered	29	6
Coal, not entire thickness, *Lower Freeport*	2	0

Reference: Section 912, Geological Survey Ohio, Fourth Series, Bulletin 35, pages 22 and 23, Lamborn.

Location: Record taken in the ravine and along the road in the south central part of Section 12, Brush Creek Township, Jefferson County. Salineville topographic sheet.

Conemaugh Series:		Ft.	In.
Sandstone, thin bedded, *Cow Run*		40	0
Clay, blue, arenaceous		2	2
Clay, yellow, *Anderson* horizon		3	0
Shale, arenaceous		1	2
Sandstone, shaly		4	7
Shale, drab-colored, arenaceous		16	1
Limestone, bluish	*Cambridge*	1	2
Shale, bluish, fossiliferous	*Cambridge*	2	2
Shale, with thin coal bands, *Wilgus*		0	1
Clay, gray		5	0
Covered		5	4
Shale, bluish-gray, arenaceous		30	0
Shale, black, with iron ore nodules	*Upper Brush Creek*	5	4
Shale, black, fossiliferous	*Upper Brush Creek*	5	0
Limestone, black	*Upper Brush Creek*	1	2
Shale, black, micaceous	*Upper Brush Creek*	4	0
Clay shale, dark, fossiliferous	*Upper Brush Creek*	7	8
Coal, bony, *Brush Creek*		0	9
Clay, bluish-gray, arenaceous		6	8
Shale, bluish-gray, arenaceous		12	10
Shale, sandy, fossiliferous	*Lower Brush Creek*	0	3
Limestone, black, ferruginous	*Lower Brush Creek*	0	3
Shale, black	*Lower Brush Creek*	0	10
Shale, black, ferruginous, fossiliferous	*Lower Brush Creek*	0	2
Shale, black, sparingly fossiliferous	*Lower Brush Creek*	2	9
Shale, black, very fossiliferous	*Lower Brush Creek*	2	2
Shale, gray, arenaceous		12	2
Shale, black, with plant impressions, *Mason* coal horizon		0	8
Clay, bluish-gray, arenaceous		4	8
Sandstone, heavy bedded, *Upper Mahoning*		9	5

		Ft.	In.
Clay, bluish-gray, arenaceous		5	0
Covered		15	8
Sandstone, cross-bedded, *Lower Mahoning*		44	4
Allegheny Series:			
Shale, black, with thin coal bands, *Upper Freeport*		0	7
Clay, bluish-gray, arenaceous		4	0
Sandstone		1	0
Clay, ferruginous, arenaceous		2	6
Clay shale, blue		10	6
Sandstone, heavy bedded	*Upper Freeport*	5	0
Sandstone, platy		31	0

Reference: Section 907, Geological Survey Ohio, Fourth Series, Bulletin 35, page 119, Lamborn.

Location: An excellent exposure of the Brush Creek beds occurs in the southern part of Section 13, Brush Creek Township, Jefferson County. Salineville topographic sheet.

		Ft.	In.
Limestone	*Cambridge*	1	2
Shale, blue, fossiliferous		2	2
Shale, with coal bands, *Wilgus*		0	1
Clay, bluish		5	0
Covered		5	4
Shale, bluish gray, arenaceous		30	0
Shale, black, carbonaceous, with ore nodules		5	4
Shale, black, arenaceous, fossiliferous		5	4
Limestone, black		1	2
Shale, black, micaceous		4	0
Shale, dark, fossiliferous		7	8
Coal, bony, *Brush Creek*		0	9
Clay, bluish-gray, arenaceous		6	8
Shale, bluish-gray		12	10
Sandstone, dark, fossiliferous	*Lower Brush Creek*	0	3
Limestone, black, ferruginous		0	3
Shale, black		0	10
Shale, black, fossiliferous		5	5
Shale, gray, arenaceous		12	2
Shale, black, with plant impressions		0	8
Clay, bluish-gray, *Mason*		4	8

BARTON COAL HORIZON

Throughout most of the field in Ohio, the Barton coal is overlain by sandstones and shales with little or no evidence of either plant or animal life. The coal is poorly developed and very patchy in extent.

Reference: Section 43, field notes, Muskingum County, Lamborn.

Location: Section along north and south road in the southeastern part of Section 14, Union Township, Muskingum County. Philo topographic sheet.

	Ft.	In.
Sandstone, shaly	5	0
Shale, gray, sandy	10	0
Coal blossom, *Pittsburgh*	1	0
Clay shales and covered with lumps of limestone	2	0
Shales and covered	31	0
Shales, gray, sandy	36	0
Covered	10	0

	Ft.	In.
Shales, gray, sandy	44	0
Limestone, *Ames*	0	10
Shales, gray, sandy	21	0
Covered	10	0
Shales, with layers of shaly sandstone	5	0
Shales, rather siliceous	5	0
Covered	10	0
Shale, bony, black, fissile, plant fossils numerous, Barton coal horizon	0	10
Covered	0	6
Clay, gray, rather plastic	4	6

HARLEM COAL HORIZON

The Harlem coal, lying about the middle of the Conemaugh series, is the highest coal of any importance in this group of rocks. It is easily placed as it lies not far below the Ames limestone.

Reference: Section 151, field notes, Muskingum County, Stout.

Location: Record taken along the deep ravine in the east central part of Section 28 and the southwestern corner of Section 27, Bluerock Township, Muskingum County. Philo topographic sheet.

		Ft.	In.
Shales, grayish yellow		1	0
Clay, limestone and covered		30	0
Shales, red, part covered, "Big Reds"		83	0
Sandstone, shaly		3	0
Clay shale, red, part covered		6	0
Limestone, ferruginous, fossiliferous, *Skelley*		0	4
Clay shales, red, part covered		22	8
Sandstone, calcareous, fossiliferous, *Gaysport*		1	0
Shales, gray		21	0
Limestone, *Ames*		1	7
Sandstone, shaly		2	0
Shale, siliceous, blue		26	0
Shale, dark, with thin bone bands, plant fossils abundant		1	0
Coal, bony	*Harlem*	0	6
Shale, dark	*Harlem*	0	5
Coal, good	*Harlem*	0	10
Clay, siliceous		2	0
Sandstone, shaly		2	0
Shale, gray		4	0
Coal	*Barton*	0	1
Shale	*Barton*	0	3
Coal	*Barton*	0	2
Clay shales		2	0
Sandstone, shaly		3	0
Shales, gray		8	0
Shales, black, with thin coal bands		2	0
Clay, very siliceous		1	6
Sandstone, with ore nodules		3	0

Reference: Section 1,134, Geological Survey Ohio, Fourth Series, Bulletin 35, page 198, Lamborn.

Location: The different members of the Pennsylvanian system from the Wilgus coal horizon to the Pittsburgh sandstone are shown along the tributary of Wells Run which heads near

Altamont Park in Section 28, Steubenville Township, Jefferson County, where the following section was measured. Steubenville topographic sheet.

	Ft.	In.
Sandstone, coarse, friable, *Pittsburgh*	24	0
Shale, gray, arenaceous	2	6
Coal blossom, *Pittsburgh*	3	0
Shale and covered	20	8
Clay, light, plastic	5	0
Shale, gray, arenaceous	51	8
Clay, calcareous	5	0
Limestone, light, *Clarksburg*	0	8
Clay, greenish-gray	2	0
Shale, calcareous, arenaceous	3	2
Shale, mottled	21	0
Shale and covered	25	10
Sandstone, *Morgantown*	27	0
Limestone, *Ames*	1	0
Shale and covered	23	10
Shale, black, with plant impressions	0	2
Coal, *Harlem*	1	6
Clay and covered	5	0
Sandstone, shale and covered	51	6
Shale, gray, arenaceous	20	0
Shale, with nodules of very ferruginous, calcareous, fossiliferous limestone, *Cambridge*	2	0
Coal smut, *Wilgus*	0	1
Clay, red to green	10	0

UPPER PART OF THE CONEMAUGH SERIES

In Ohio the interval from the Ames limestone to the Pittsburgh coal varies from 155 feet in Meigs County to 220 feet in Jefferson County. In general the formations in this section are extremely variable and locally wanting. The replacement may be 50 to 100 feet of clay shales, red in color and soft and structureless in character. These are known collectively to the geologist and driller as the "Big Reds." Such deposits in some areas appear to yield silicified wood and in others they contain many nodules of hematite, a few of which will yield well preserved plant remains.

SILICIFIED WOOD

Silicified wood in the red shales above the Ames limestone is abundant along the streams in Morgan Township, Gallia County.

"Near the head of Middle Branch of Shade River, in Section 1, Athens Township, Athens County, many specimens of silicified wood were seen in the bed of the creek, and many fine museum specimens have been taken from this locality. No blocks were seen in place in the hills, but it is probable that they have weathered out from shales lying a little higher [?] than the Pittsburgh coal."[1]

"Specimens of silicified wood are common in the hills of this region, (northwestern Homer Township, Morgan County) but none was seen in place. Loose blocks were found well up in the hills, and it is probable that they have weathered from shale lying a little above the Ames limestone."[2]

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[1]Geological Survey Ohio, Fourth Series, Bulletin 17, pages 119–120.
[2]Geological Survey Ohio, Fourth Series, Bulletin 17, page 140.

HEMATITE NODULES

Hematite can be found in some quantity in most of the streams in eastern Athens, eastern Perry, and western Morgan Counties. In some areas there are only a few scattered nodules; in others it is so thick that from one to two pounds may be picked from a square foot of surface. Some favorable places are: on the headwaters of Bryson Run, Section 36, Ames Township, Athens County; another is near Sayre in Bearfield Township, Perry County; and near Ringgold in Union Township, Morgan County. Similar deposits are found in eastern Lawrence and western Gallia Counties. Only a few of the nodules contain plant fossils. The plant fragments, however, are exceptionally well preserved.

MONONGAHELA SERIES

The Monongahela series, averaging about 245 feet in thickness, is made up largely of freshwater limestones, calcareous shales, and sandstones. It contains seven coal beds some of which, Pittsburgh, Pomeroy, and Meigs Creek, are of great economic importance. The period was thus of organic origin and in some of the strata much evidence of the plant life prevails. Only a few of the better localities will be considered.

PITTSBURGH COAL HORIZON

In Ohio the Pittsburgh is a well marked horizon from Jefferson County on the north to Lawrence County on the south. The chief productive fields are the Eastern Ohio field in Jefferson, Harrison, Belmont, Monroe, and Guernsey Counties, the Federal Creek field in Athens and Morgan Counties, and the Swan Creek field in Gallia County. The roof shales in many mines bear some plant fossils.

Reference: Section 810, field notes, Athens County, Stout.

Location: Up the Marietta road at the Sharpsburg Hill, northeast Section 29, Berne Township, Athens County. Chesterhill topographic sheet.

	Ft.	In.
Sandstone, shaly	2	0
Shale, siliceous, gray	1	6
Coal, shaly, *Little Waynesburg*	0	2
Clay, calcareous, grainy, gray to pink, parts marly	10	9
Sandstone and shale, gray	22	1
Limestone, nodular, pinkish	0	8
Shale, pink, calcareous, parts gray	22	1
Sandstone, shaly, gray	2	0
Shale, pink, sandy	2	0
Coal smut, *Uniontown*	0	1/16
Shale, pink to gray, calcareous, parts marly	21	9
Shale and shaly sandstone	10	0
Shale, pink	2	6
Coal smut, (*Arnoldsburg?*)	0	6¼
Shales, calcareous	10	5
Limestones and calcareous shales, *Arnoldsburg-Benwood*	48	0
Sandstone, massive, irregular, *Upper Sewickley*	6	2
Shale, gray, siliceous	3	4
Coal smut, *Meigs Creek*	0	0½
Shale, calcareous, blue to buff	8	8
Shale, gray, parts very sandy	9	4
Clay, dark, smutty, *Fishpot* coal horizon	0	2
Clay shale, dark	1	0
Limestone, thin to massive, with thin shale partings	7	0
Shale, pink, marly	19	6
Limestone, sandy, yellowish	1	10

		Ft.	In.
Shale, calcareous, gray to green to pink, marly with thin limestone layers		22	2
Shale and shaly sandstone		15	4
Shale, with plant fossils, roof of coal		1	0
Coal, good	*Pittsburgh*,	5	4
Clay, soft, gray	mine of Eckard and Day,	0	11
Coal, good	elevation 915 feet	3	9

Reference: Section 812, field notes, Athens County, Stout.

Location: Mine of L. E. Harris on the G. W. Selby land, northeast Section 30, Berne Township, Athens County. Chesterhill topographic sheet.

		Ft.	In.
Sandstone, massive, *Upper Pittsburgh*		20	0
Shale, dark, with plant fossils		1	5
Coal, with thin partings		3	0
Shale, with pyrite		0	0¼
Coal, good		0	1
Shale, hard, bony	*Pittsburgh*	0	11
Coal, good		0	4½
Clay, gray, soft		1	2½
Coal, good		3	9

Throughout most of the Federal Creek field the roof of the Pittsburgh coal yields plant fossils in fair abundance and with good detail.

Reference: Section 299, Geological Survey Ohio, Volume 1, page 298.

Location: In Section 34, Homer Township, Morgan County, on land of Mr. Bishop, the following section was taken (coal near top of high knob). New Lexington topographic sheet.

		Ft.	In.
Limestone, buff		1	0
Covered		27	0
Coal		3	0
Clay, with coal plants	*Pittsburgh*	1	0
Coal		4	0
Covered		142	0
Limestone, *Ames*		2	6

Reference: Section 298, Geological Survey Ohio, Volume 1, page 298.

Location: The following section of the (Pittsburgh) coal was taken on the land of J. Stinchcomb, Section 29, Homer Township, Morgan County. (This coal lies close to the top of the high ridge). New Lexington topographic sheet.

		Ft.	In.
Limestone, buff		1	0
Covered		12	0
Sandstone, *Upper Pittsburgh*		6	0
Shale, with coal plants		10	0
Coal		4	2
Clay	*Pittsburgh*	1	0
Coal		4	0
Covered		143	0
Limestone, *Ames*		2	0

Reference: Section 13, Washington County, Thesis, 1936, John C. Frye, State University, Iowa.

Location: On Cat Creek, about one mile southwest of the Noble-Washington County line, north of the stream, in the northeastern part of Adams Township, Washington County, the following rocks were exposed. Macksburg topographic sheet.

	Feet
Coal, *Meigs Creek*	2.0
Shale, gray, carbonaceous	4.0
Covered	35.4
Limestone, gray	0.8
Sandstone, fine grained, gray	3.5
Shale, calcareous, gray, fissile	3.8
Limestone, gray	0.2
Shale, calcareous	1.0
Shale and limestone, gray	3.5
Shale and covered	2.6
Shale, calcareous, gray, black and red	1.5
Sandstone, gray, fine grained	19.0
Covered	5.5
Shale, gray, calcareous	0.9
Shale, carbonaceous	0.08
Shale, very calcareous. The following plants collected: Pecopteris, several species; Neuropteris; Odontopteris; Equistides?	2.1
Shale and covered	8.0
Coal, *Pittsburgh*	0.2
Limestone, black, shaly	0.9

Base of section in Cat Run at an elevation of 780 feet.

REDSTONE OR POMEROY COAL HORIZON

The Redstone or Pomeroy coal is widely distributed in Ohio but the field of economic importance is confined to southern Meigs and eastern Gallia Counties. In many localities the roof shales of this coal contain plant fossils in a fair state of preservation.

Reference: First Annual Report on the Geological Survey of Ohio, 1838, report of Dr. S. P. Hildreth, pages 42 and 43. Fossils which accompany "The Pomeroy Coal Bed" [Redstone].

Location: At Pomeroy, Meigs County.

"In the shale beds, which generally form the roof of this coal, we find innumerable casts and impressions of the foliage and stems of various coal plants, of which have been collected more than twenty species. Amongst them may be recognized of the *Equisetaceae*, the *Calamites* and *Equiseteum* of *Filices*, the *Sphenopteris*, *Glossopteris*, *Neuropteris*, *Pecopteris*, etc. The Lycopodiaceae, such as *Lepidodendron*, *Sigillaria*, etc., are rare in this deposit, but are common in the earlier formed beds. The most interesting feature of the rocks connected with this coal, is the great abundance of fossilized stems and branches of trees, that are found to accompany the coarse sandrocks which lie over the coal, in several localities which have been visited. So few quarries, or excavations, have been yet opened in this rock, that we can only discover them in beds of streams, or situations where the rock has crumbled away by natural causes."

Reference: Section 253, Geological Survey Ohio, Volume 1, page 253.

Location: A section at Pomeroy shows the following strata. Pomeroy topographic sheet.

	Ft.	In.
Shale	6	0
Sandstone, laminated	6	0
Clay shale	10	0
Sandstone	16	0
Not exposed in detail	31	0
Shale, red	6	0
Sandstone, compact	9	0
Shale	18	0
Sandstone, heavy, (*Pomeroy*)	64	0
Shale, sandy, with coal plants	9	0

		Ft.	In.
Coal, top	*Pomeroy or Redstone*	1	0
Shale		0	2
Coal		4	0
Shale, bituminous, with streaks of coal		1	2
Clay		1	0
Sandstone		8	0
Shale		6	0
Sandstone		2	0
Shale		14	0
Pittsburgh coal not far below.			

Reference: Section 254, Geological Survey Ohio, Volume 1, page 254.

Location: At Coalport (midway between Pomeroy and Middleport) we find the coal (Pomeroy) and its associated strata as follows. Pomeroy topographic sheet.

		Ft.	In.
Sandstone, heavy, not measured		..	..
Shale, ferruginous, containing coal plants		15	0
Shale, bituminous		0	8
Coal	*Pomeroy or Redstone*	1	6
Coal		3	7
Underclay and shale		6	0

Reference: Section 250, Geological Survey Ohio, Volume 1, page 250.

Location: At the Wells bank, a mile east of Pagetown, in the southeastern part of Section 17, Scipio Township, Meigs County, the following measurements were made. Pomeroy topographic sheet.

	Ft.	In.
Sandrock, seen	20	0
Shale, with coal plants	4	0
Coal, [*Pomeroy or Redstone*]	3	6

Reference: First Annual Report on the Geological Survey of Ohio, 1838, Report of Dr. S. P. Hildreth, page 43.

Locations: Branches of Federal Creek, (Morgan and Athens Counties), Leading Creek (western Meigs County), Campaign Creek (northern Gallia County), head of Shale River, Lodi Township, Athens County.

"Fragments of fossilized trees are seen in several of the branches of Federal Creek; the beds of Campaign and Leading Creek, but more abundantly in the heads of Shade River, Township of Lodi, Athens County. The extreme northerly branch of this river, rises in that high ridge of land south of Athens, before noticed, and not more than a mile from the Hockhocking River. About three miles south, this branch becomes a rivulet of ten or twelve feet in width. In the bed of this rivulet, and also in one which heads with it, and puts into the Hockhocking, are found numerous tabular, oval masses of siliceous composition. They are from 4 to 10 inches in thickness, and from 2 to 3 feet in diameter, with others that are smaller. One of the sides is almost invariably concave, or depressed in the center, and the opposite one plane or slightly convex. They are evidently petrifications of some vegetable substance, as the traces of the fibrous structure is very apparent in all the specimens. The form of these masses very much resembles that of the base of the *Stigmaria ficoides*, with the branches all broken off. They are composed of the hardest silicious matter, of a reddish, gray color. . . . Isolated masses are scattered along the bed of the branch for more than a mile, the bottom of which is composed of a slaty sand-rock, deposited in thin layers, highly inclined, and of slight coherence. No specimens were found in place, but they were doubtless originally imbedded in a coarse sand-rock, which lies over the coal. This opinion is strengthened by the fact that portions of the trunks and roots of the fossil trees found lower down the branch, are often ploughed up in the fields, on the hill sides, 50 to 80 feet above the bed. A few miles lower down, and six and a half miles from Athens, the beds of several small streams, all tributaries of Shade, and rising over a space of 8 or 10 square miles of surface, are found strewed with

the segments of trunks of fossil trees, varying in diameter from a few inches to 18 or 20 inches. The larger sections are generally perforated by a circular opening near the center, from 1 to 4 or 5 inches in diameter. The regular shape of the pieces, resembling transverse sections of a log of wood, seems to be the result of a peculiar mineral organization, disposing the fragments to assume a cubic form, had the exterior of the fossil been square instead of circular. The ligneous structure of the original tree was coarse, very distinct, and highly vascular; it is now replaced by silex, in many specimens beautifully agatized. Some of the pieces are filled with perforations, the size of a quill, and larger, which seem to have been made by a worm. This most probably was done by an ancient Teredo, after the trees were torn up, and floated down some river to the ocean. Fragments, three to four feet in length, are the longest yet discovered. The quantity of specimens is so great that we might be led to suppose a whole forest had originally been entombed in this place, covered with beds of a highly silicious quality, and consolidated into sand-rock. These rocks being less dense and compact than the fossilized wood, have, in the course of ages, crumbled into soil, and left the imbedded trees to fall out in fragments, and gradually wash down the slopes of the hills into the beds of the streams, where they are now found. As the age of this rock is long anterior to the Tertiary, these fossil remains are not likely to be allied to any living species of tree which now vegetates in the forests of Ohio. It most probably belongs to the tribe of Gymosperma, of Lindley; a race of plants whose seeds are naked or formed without a pericarpium, or envelope. From the great vascularity of the trunk, and the fact of the fragments almost entirely composed of the shafts of the trees, with few or no branches, we are led to conclude, they may be attached to the order Cycadea, the woody fibre of which is very similar in structure to the coniferae, or pine race, and which are only found in some of the more recent coal deposits."

Reference: Section 286, Geological Survey Ohio, Volume I, pages 287–288.

Location: The following is a section obtained on the land of Philip Haning in Section 32, Lodi Township, Athens County. Pomeroy topographic sheet.

	Ft.	In.
Sandstone, seen, *Pomeroy*	25	0
Sandstone, unevenly bedded, showing part of a trunk of a silicified tree in place	5	0
Shale, blue, with coal plants	5	0
Coal, reported, *Pomeroy* or *Redstone*	1	6
Shale, with nodules of limestone	25	0
Coal, *Pittsburgh*	3	0
Shale and clay	12	0

"The above section is of great interest as showing the position of one of the trunks of petrified wood. These trunks are very often found on the upper branches of Shade River, lying in the bed of the stream.

"Great quantities, even tons, of specimens of silicified wood from Shade River, have been obtained to enrich cabinets in various parts of the country. No very minute investigation has as yet [1873] been made of the samples so far as I know. Mr. Leo Lesquereux is now engaged in the study of them, and it is believed that his results will be interesting and valuable. There are doubtless many different kinds of wood, and when specimens are properly prepared for microscopic investigation, the structural differences will be still more apparent. Mr. Lesquereux believes that the fragments of trunks are found in the shales between the two coals [Pittsburgh and Pomeroy], as well as in the sandstone above the upper coal [Pomeroy] where I [Andrews] found them. From repeated visits to this region, I am led to believe that the trees, after drifting about and many of them partly rotting away, were buried in the sand, and while thus buried, were slowly changed into silex from silica derived, probably, from the sand of the sandrock. The portion of a trunk seen in place on the Haning farm, had more than half rotted away before it was silicified. It lies in the sandrock in a horizontal position, and the false bedding of the sandrock around it indicates the rolling of waves upon a sandy beach.

"One of the most interesting of the Shade River petrifications is a peculiar disc, often three or four feet in diameter, composed of a mass of flattened rootlets, resembling somewhat those of *Stigmaria*. These rootlets radiate from a common center, and evidently grew in a dense

bunch around the Psaronius tree. The tree, however, is generally gone, either leaving a cavity in the center of the disc, or a depression upon both the upper and under sides. Many years ago, I [Andrews] found one of these discs, showing the remains of a central trunk. The tree had fallen and evidently pressed upon one side of the mass of rootlets, and had in that position partly rotted away before the whole had become silicified."

MEIGS CREEK OR SEWICKLEY COAL HORIZON

The main field of the Meigs Creek coal extends from the Muskingum River in Morgan County to Short Creek in southern Jefferson County. Locally the overlying shales bear some plant fossils and in a few places they contain much fine material.

Reference: Section 11, Thesis, 1936, John C. Frye, State University of Iowa.

Location: Section measured on west side of Big Run, one and one-fourth miles south of the mouth of Straight Run in western Adams Township, Washington County. Caldwell topographic sheet.

	Feet
Shales, mostly covered	27.5
Sandstone and covered	22.0
Sandstone, ferruginous, dark brown	0.9
Sandstone, gray, with shale partings	5.6
Shale, red, partly covered	7.7
Sandstone	5.0
Shale, mostly covered	15.2
Covered	20.0
Sandstone, fine grained, gray	7.5
Covered	3.0
Shale, red	8.0
Shale, gray	2.3
Sandstone, fine grained, gray	1.7
Shale, fissile, red and gray	7.7
Covered	66.0
Limestones	2.3
Shale, micaceous, dark green	7.5
Sandstone, tan, *Upper Sewickley*	21.5
Shale, dark gray, upper part fissile, contains *Calliptoridium?*, *Neuropteris*, *Nematophyllum*, *Odontopteris*, *Pecopteris*, *Shenophyllum*	3.0
Coal — *Meigs Creek*	0.9
Shale, dark gray — *Meigs Creek*	1.1
Coal — *Meigs Creek*	1.6
Covered — *Meigs Creek*	1.3
Shale, gray and tan — *Meigs Creek*	5.0

Reference: Section 661, field notes, Noble County, Stout.

Location: Record located on the East Fork of Duck Creek, one and one-half miles northeast of Lower Salem, south of the stream, near the southwest corner of Section 36 (in part), Salem Township, Noble County, at the coal mine of A. H. Ullman. The record taken is given below. Macksburg topographic sheet.

		Ft.	In.
Sandstone, massive, *Upper Sewickley*		20	0
Shale, calcareous, with many plant fossils		1	1
Shale, coaly		0	1
Coal, good	*Meigs Creek*	2	0
Shale, gray	*Meigs Creek*	0	0½
Coal, fair	*Meigs Creek*	0	1
Clay shale	*Meigs Creek*	1	1
Coal, good	*Meigs Creek*	3	0½
Covered		73	0

Road level, elevation 730 feet.

Permian System

In Ohio the Permian system of rocks extends in a narrow belt along the Ohio River from Jefferson County on the north to Meigs County on the south. The total area is close to 1,830 square miles and the maximum thickness about 625 feet. The system is divided into two major divisions, Washington and Greene series, and these are further subdivided into many members. The rocks of the Permian system, in Ohio, consist largely of shales, sandstones and freshwater limestones. While coal beds are present and about normally spaced they are usually impure and in some cases mere soot streaks of organic matter. As so far examined the fossil plants are confined to the lower or Washington series.

THE WASHINGTON FORMATION[3]

"As indicated elsewhere, the Washington formation begins with the Cassville shale and ends with the Upper Washington limestone or the horizon of the Jollytown "A" coal. This formation, in general, is not very prolific in fossils. It has, however, a better preservation of the Dunkard life than is to be found in the overlying beds. Plants are the most abundant fossils in the Dunkard series. At certain horizons the shales are crowded with plant remains in various stages of preservation. In West Virginia and Pennsylvania, William M. Fontaine and I. C. White found 107 different species of fossil plants in the Cassville shale. Fragments of many of these are to be found in the shales of the same horizon in Ohio.

"The shales of the Washington formation often contain fossil plants. These are usually more abundant in the beds associated with the coal. Most, probably all, of these plants have been found in correlative beds of Pennsylvania and West Virginia.

"The following list represents the more important ones found in Ohio.

Pecopteris imbricata, Fontaine and White
Cassville shale, Paines Run, near Cameron..... (1)
Pecopteris dentata (Bat)
Cassville shale, Paines Run, near Cameron..... (2)
Pecopteris heeriana, Fontaine and White
Cassville shale, Paines Run, near Cameron..... (3)
Pecopteris subfalcata, Fontaine and White
Cassville shale, Clarington [appears to be Uniontown]..... (4)
Pecopteris tenuinervis, Fontaine and White
Cassville shale, Becket Station, also in shales above the Waynesburg 'A' coal..... (5)
Neuropteris flexuosa longifolia, Fontaine and White
Cassville shale, Clarington [appears to be Uniontown]..... (6)
Neuropteris sp.
Washington coal, Crabapple..... (7)
Callipteridium grandifolium, Fontaine and White
Cassville shale, Clarington [appears to be Uniontown]..... (8)
Callipteridium sp.
Cassville shale, Paines Run, near Cameron..... (9)
Callipteris sp.
Cassville shale, Vallonia..... (10)
Callipteridium dawsonianum, Fontaine and White
Cassville shale, Paines Run, near Cameron..... (11)
Rhacophyllum filiciforme majus, Fontaine and White
Cassville shale, Paines Run, near Cameron..... (12)
Alithopleris virginiana, Fontaine and White
Cassville shale, Paines Run, near Cameron..... (13)
Sphenophyllum latifolium? Fontaine and White
Upper shales of Washington formation, Tunnel Station..... (14)

[3]Geological Survey Ohio, Fourth Series, Bulletin 22, pages 141, 142-143.

Baiera virginiana, Fontaine and White
Washington coal, Crabapple.....(15)
Sigillaria sp.
Washington coal, Crabapple.....(16)
Spore cases
Washington coal, Crabapple.....(17)
Rhacophyllum filiciforme
Shales above Waynesburg 'A' coal, Clarington.....(18)
Annularia sp.
Shales above Waynesburg 'A' coal, Clarington.....(19)
Cordaites sp.
Shales above Waynesburg 'A' coal, Clarington.....(20)
Calamocladus sp.
Shales above Waynesburg 'A' coal, Clarington.....(21)"

PAINES RUN LOCALITIES

Paines Run is located north of Cameron in southwestern Switzerland, northeast Adams and west central Salem Townships, Monroe County. The horizon of the Cassville shale is about 840 feet at the mouth of the stream and 885 feet in the northern part of Section 15, Switzerland Township, where it passes below drainage. Three sections are given below:

Reference: Section 424, field notes, Monroe County, Stout.

Location: In hollow west of the stream in the northeast part of Section 14, Adams Township, Monroe County, the following strata were exposed. Clarington topographic sheet.

		Ft.	In.
Shale, gray		2	3
Limestone, blue, hard	*Elm Grove*	0	8
Limestone, blue, hard		0	7
Limestone, blue, nodular		0	3
Shale, blue		0	1
Limestone, blue, hard		1	2
Shale, gray, with fossils, *Cassville*		7	0
Covered		37	7
Shale, gray, siliceous		13	0
Shale, bony, dark	*Uniontown*, not full thickness,	0	2
Coal, good	elevation 790 feet	1	8

Reference: Section 422, field notes, Monroe County, Stout.

Location: On Paines Run east of the stream, north of the center of Section 15, Switzerland Township, Monroe County. Clarington topographic sheet. The record taken is given below:

		Ft.	In.
Shale, gray to dark		10	0
Limestone, hard, blue, blocky	*Elm Grove*	0	7
Limestone, hard, blue, blocky		1	9
Shale, dark		0	5
Limestone, three layers		0	11
Shale, dark, soft, plant remains, *Cassville*		3	5
Shale, dark, carbonaceous		0	3
Shale, carbonaceous, hard, bony		0	1
Coal, rough, *Waynesburg*, elevation 880 feet		0	10
Shale, bony		0	0¼
Clay shale, blue to gray		5	9
Shale, blue, with ore nodules and thin sandstone layers		4	3

Reference: Section 421, field notes, Monroe County, Stout.

Location: In bed of stream near line of Section 15 and Section 16, Switzerland Township, Monroe County. Clarington topographic sheet. The record follows:

		Ft.	In.
Limestone, blue, blocky	*Elm Grove*	2	2
Limestone, blue, blocky		0	7
Shale, blue		1	7
Clay shale, dark	*Cassville*	0	6
Clay shale, bluish gray		1	0
Shale, coaly	*Waynesburg*	0	2½
Coal, bony		0	1
Coal, good		0	4¾
Clay, impure		1	0

CLARINGTON LOCALITIES

In this locality the Cassville shale is found at an elevation close to 700 feet and the Waynesburg "A" coal at 750 feet.

Reference: Section 154, field notes, Monroe County, Stout.

Location: Up the ravine at the west end of the bridge at Clarington, northwest corner Section 24 and the northeast corner of Section 30, Salem Township, Monroe County, the following beds were measured. Clarington topographic sheet.

		Ft.	In.
Washington series, Permian system:			
Coal prospect, *Washington*		3	0
Shales, gray, parts covered		28	0
Coal smut, *Little Washington*		0	1
Clay shale, dark		2	11
Sandstone, shaly		8	0
Shales, gray, mainly siliceous		29	4
Coal prospect and covered, *Waynesburg* "A"		5	4
Limestone, hard, dark		1	2
Covered		5	2
Shale and shaly sandstone		15	0
Sandstone, shaly		7	0
Covered, Cassville shales here		10	8
Monongahela series, Pennsylvanian system:			
Coal, bony, and shale, dark, *Waynesburg*		0	6
Shale, gray, and sandstone, shaly		18	4
Soot streak		0	1
Clay shale, dark		3	0
Shale, gray, parts very sandy		7	5
Shale, dark, argillaceous		1	0
Coal, shaly, *Little Waynesburg*		0	3
Clay shale, calcareous, dark		7	9
Shale and shaly sandstone, gray		18	0
Shale, gray, siliceous, with plant fossils		7	0
Coal, good	*Uniontown*	1	9½
Coal, shaly		0	2
Shale, coaly		0	2
Shale, gray		0	2
Coal, fair		0	3½
Shale, gray, calcareous	*Uniontown*	1	2
Limestone, irregular		1	6
Shale, gray, very siliceous		5	10
Sandstone, shaly, *Arnoldsburg*		1	4
Shales, gray to pink		5	8
Shale, dark		0	4
Limestone, shaly	*Arnoldsburg*	1	5
Limestone, hard, light		1	3
End of bridge, elevation 620 feet approximately		..	..

Reference: Section 152, field notes, Monroe County, Stout.

Location: Section taken along the road that leads from Stillhouse Run, near its mouth, to the ridge north, in the northeastern part of Section 20, Salem Township, Monroe County. Clarington topographic sheet.

		Ft.	In.
Coal blossom, *Washington*		3	0
Shales and covered		11	6
Sandstone, massive	*Mannington*	18	0
Shale, gray		4	0
Sandstone, massive		19	0
Shales, gray		13	0
Clay shale, dark		1	0
Coal, weathered, shaly, *Waynesburg "A"*		4	0
Shales, parts covered		29	0
Sandstone, shaly		10	0
Shale, gray, Cassville		8	0
Shale, dark, *Waynesburg* coal horizon		1	0
Shales and shaly sandstone		11	4
Shale, dark		0	8
Shale, gray		6	0
Sandstone, shaly		2	0
Shale, part calcareous		6	0
Covered		22	6
Sandstone, shaly		2	6
Shale, gray		6	10
Sandstone, shaly		1	2
Shale, gray, plant fossils		3	10
Coal, weathered, *Uniontown*		3	2
Shale, gray		12	5
Sandstone, massive		1	5
Shale, gray, siliceous		3	4
Limestone and calcareous shale		1	6
Limestone, hard, light		0	10
Shale, calcareous, with limestone nodules		1	6
Limestone, hard, light		1	6
Valley floor, elevation 650 feet		..	..

VALLONIA LOCALITY

Along Weegee Creek in the vicinity of Vallonia the Cassville shales are found at an elevation close to 950 feet. The Cassville shale is overlain by the Elm Grove limestone and underlain by the Waynesburg coal.

Reference: Section 31, field notes. Belmont County, Stout.

Location: Record taken at Vallonia, along Weegee Creek, south of the center of Section 14, Mead Township, Belmont County. St. Clairsville topographic sheet.

	Ft.	In.
Shale, dark, carbonaceous	2	0
Limestone, *Elm Grove*	1	10
Shale, gray, siliceous, *Cassville*	4	6
Coal blossom, *Waynesburg*	1	0
Shales, gray, part sandy	11	6
Coal, shaly, *Little Waynesburg*, elevation 938 feet	0	3½
Shale, light	0	3
Limestones, massive	3	4
Limestones, calcareous shales and covered	11	4
Sandstone, hard, blue, calcareous	2	0

BECKET STATION LOCALITY

In this locality the Cassville shales are present at an elevation of 1,060 feet. In this area both the associated Elm Grove limestone and the Waynesburg coal are present in good development and act as benches of reference.

Reference: Section 117, field notes, Belmont County, Stout.

Location: Section taken at the trestle of the Ohio River and Western Railroad (abandoned) along Rocky Fork, in the northeastern part of Section 12, Washington Township, Belmont County. Clarington topographic sheet.

		Ft.	In.
Limestone, hard, dark	*Elm Grove*	1	4
Shale, gray	*Elm Grove*	8	1
Limestone, dark, very siliceous	*Elm Grove*	1	8
Shale, siliceous, dark, with plant fossils, Cassville		4	7
Sandstone, shaly		1	0
Shale, siliceous		0	6
Sandstone, micaceous		0	10
Shale, coaly		0	2
Coal, good, *Waynesburg*		2	3
Shale, gray		0	10
Sandstone, shaly		4	0

CRABAPPLE LOCALITY

North of Crabapple the Waynesburg coal is mined in a small way. It is present at an elevation of 910 feet and the Washington coal lies approximately 100 feet higher.

Reference: Section 70, Geological Survey Ohio, Fourth Series, Bulletin 22, page 70.

Location: Section located north of Crabapple in the north-central part of Section 26, Washington Township, Belmont County. Clarington topographic sheet.

	Ft.	In.
Sandstone, laminated, micaceous, gray, *Lower Marietta*	16	0
Shales, red and gray, argillaceous, with plant fossils	19	3
Coal and shale, *Washington*	3	5
Covered	26	8
Shale, argillaceous, blue, with sandy nodules	10	8
Covered	14	0
Limestone, dark	0	6
Shale, black, carbonaceous, and some coal. At some places this coaly portion thickens to a foot and has been mined, *Waynesburg "A"*	1	10
Limestone, blue-gray, hard	0	10
Limestone, dark-gray, impure	1	1
Shale, dark-gray	1	6
Limestone, gray to yellow	3	3
Sandstone, massive, gray	4	7
Shale, gray	7	6
Limestone, gray, with an irregular base	1	6
Shale, soft, gray, with calcareous nodules and black carbonaceous streaks at base	4	5
Shale, gray, contorted, nodular, sandy, micaceous	5	4
Sandstone, gray, shaly, micaceous	2	6
Shale, gray, arenaceous, containing plant remains	4	5
Shale, gray, arenaceous	0	5
Sandstone, gray, arenaceous	0	6
Shale, blue, argillaceous, rather soft	2	0
Coal and carbonaceous shale, a small country mine, *Waynesburg*	3	8

TUNNEL STATION LOCALITY

Reference: Section 130, Geological Survey Ohio, Fourth Series, Bulletin 22, pages 130–131.

Location: "At Tunnel Station, on the Marietta, Columbus and Cleveland Railway, (abandoned) some very good outcrops of small portions of the Dunkard, (upper Washington Series) are to be seen. The grindstone quarries at this place are probably in the Jollytown sandstone, although it may possibly be Hundred in age. Combined section of quarry and tunnel cut on the Marietta, Columbus and Cleveland Railway, near the head of Browns Run, southwest Section 16, Warren Township, Washington County. Parkersburg topographic sheet.

	Ft.	In.
Shales, red and gray, argillaceous, to the top of the Cleveland Stone Company's Quarry on Charles Treachel's land	4	0
Shale, gray, arenaceous	10	8
Sandstone, gray, micaceous, rather massive. This is the rock used for grindstones. Jollytown? sandstone	16	6
Covered interval to bottom of quarry	24	4
Sandstone, gray, micaceous, laminated	1	0
Shale, red and gray, arenaceous	5	0
Covered interval with some weathered red shale exposed	17	4
Shale, red, argillaceous, to top of tunnel cut	6	0
Sandstone, calcareous, shaly, greenish-gray	2	0
Shales, red to greenish-gray	6	4
Sandstone, micaceous, shaly, greenish-gray	3	0
Shale, arenaceous, gray, nodular	0	6
Shale, red, with streaks of gray	0	8
Shale, greenish-gray with streaks of red	1	2
Sandstone, micaceous, nodular	0	3
Shales, red and gray, with nodules	0	9
Shale, red, argillaceous, containing iron nodules	11	3
Sandstone, coarse, bluish to greenish-gray, laminated, this extends to the level of the track at the upper end of the tunnel	7	2

WAYNESBURG COAL HORIZON

Locally the Waynesburg coal is much broken by shale partings, that is, it consists of thin beds of coal in carbonaceous shales which may contain plant fossils.

Reference: Section 28, Thesis, 1936, John C. Frye, State University of Iowa.

Location: A section was measured up the creek bed and road cut from the road intersection, elevation 667 feet, 1.5 miles north of Watertown, Watertown Township, Washington County. Parkersburg topographic sheet.

		Feet
Cover to top of hill		4.0
Sandstone, medium grained, buff, *Lower Marietta*		33.0
Shale, gray and tan		2.7
Clay		0.5
Coal	*Washington*	0.15
Clay		0.5
Coal, shaly		0.4
Shale, maroon, partly covered		2.8
Clay shale, red, partly covered		16.5
Sandstone, lenticular, and shale, tan		8.4
Shale, fissile, tan and red		11.9
Shale, fissile, maroon		4.0
Shale, red and gray		5.3

		Feet
Shale, arenaceous, tan		9.0
Shale, ferruginous, black		0.15
Shale, maroon		7.2
Covered		2.2
Sandstone, medium grained, gray		0.4
Shale, hard, mottled, partly covered		4.8
Shale, gray, passing upward into sandstone		5.2
Shale, highly carbonaceous		1.0
Shale, tan		3.0
Underclay, blue-gray, and shale, tan		0.6
Sandstone, fine-grained, cross-bedded		3.0
Shale, fissile, tan		5.2
Coal	*Waynesburg*	0.25
Shale, tan, with abundant plant fossils		2.2
Coal, shaly		0.15
Shale, gray and tan		13.2
Limestone, hard, gray		5.4
Road intersection, elevation 667 feet		...

WAYNESBURG "A" COAL HORIZON

The Waynesburg "A" coal horizon bears some plant fossils in many areas. Probably through careful search some rich deposits may be discovered.

Reference: Section 27, Thesis, 1936, John C. Frye, State University of Iowa.

Location: A section measured along road and draw, 1.5 miles east of Watertown, Central Section 2, Watertown Township, Washington County. Parkersburg topographic sheet.

		Feet
Cover to top of hill		30.0
Shale, arenaceous, tan		10.4
Limestone, argillaceous, buff		0.2
Shale, arenaceous, tan		5.2
Shale and sandstone		3.0
Covered		24.0
Sandstone, fine-grained, buff		4.2
Shale, fissile, maroon		0.5
Shales, red, gray and tan		17.3
Sandstone, fine-grained, light gray		2.0
Shale, arenaceous, red and gray		3.4
Shale, tan, parts covered		38.4
Sandstone, highly micaceous, fine-grained, buff		5.5
Shale, maroon, partly covered		11.6
Shale, arenaceous, tan		2.0
Shale, mostly maroon		12.4
Coal, shaly	*Waynesburg "A"*	0.5
Clay, tan		0.3
Coal, shaly, carbonaceous		0.7
Nematophyllum, Neuropteris and Pecopteris were collected from lower zone.		
Clay shale, tan and gray		5.0
Covered to level of creek above Painter Run		6.0

HIGHER HORIZONS

Reference: Grotto of plants. Observations on the Bituminous Coal deposits of the valley of the Ohio, and the accompanying rock strata; with notices of the fossil Organic remains and the relics of Vegetable and Animal bodies, illustrated by a Geological map, by numerous drawings of plants and shells, and by views of interesting scenery; by Dr. S. P. Hildreth, of Marietta, Ohio. The American Journal of Science, Volume XXIX, January, 1836, pages 18–20.

Location: The grotto is seated on the side of a deep ravine, which the water in running from the hills, has gradually worn in the rocks, at an elevation of one hundred feet above the bed of the river (Ohio). Located two miles below the mouth of the Muskingum River and 660 feet northwest from the bank of the Ohio River, northeast corner of Section 3, Warren Township, Washington County. Marietta topographic sheet.

"At the southern outlet of the Muskingum Valley, two miles below the mouth of the river, and forty rods from the bank of the Ohio, an interesting grotto, has been formed in the sandstone from the gradual disintegration of the rock by a chemical process. The rock itself or rather this stratum (Hundred sandstone) is about 50 feet in thickness. It rests on a bed of argillaceous or slaty marl, (impure fresh-water limestone) two feet thick. The upper portion is ash colored and very heavy, (limestone) and the lower portion of the bed, fourteen inches in thickness, is of a deep rich brown, or red. Its structure is slaty, and it splits easily in the line of stratification into thin layers. It is completely filled with vegetable impressions of the most perfect and beautiful structure; many of them appear to be aquatic plants, but the most abundant are of the genus Neuroptera. If the slaty matrix were less fragile, very perfect specimens could be procured. As it is, they are, in the hands of any one versed in the botany of fossil plants, sufficient to determine the species. Several figures are given of the plants found here, from No. 23 to 26; (pages 10 and 11 of the wood cuts)[4] No. 23 is one of the most beautiful and perfect branches of the arborescent fern that I have ever seen. The foliage is similar to that represented by N. Ad. Brongniart in one of his antediluvian trees, as he supposed they appeared when living. I have seen no similar species, described in his work on fossil plants. No. 24 was probably a very porous, thick leaved, aquatic plant, termination ovate, as fragments of the extremities were found, of that shape, cuticle scabrous. The leaf was replaced by a deposit of yellow ochre, one-eighth of an inch in thickness, leaving the outlines and markings of the cuticle on the red shale. A large proportion of the plants at the grotto are replaced by yellow ochre. Several other species are impressed on the same fragment. No. 25 is a very rich fern. Each leaflet appears to have been composed of, or margined by rounded grains, too large and too uniform, for the fruit. The beautiful oblong leaf, No. 26, resembles 'Neuropteris Scheuchzeri,' but is not sufficiently acuminate. Its structure is similar to that of the oleander leaf and is probably a new species. On the same fragment are two species of Neuroptera. Pods and seeds of plants are also common; with the leaf of a thick, aquatic plant, like that of the Nelumbium luteum, passing transversely through the bed, as if they had been inhumed in their growing and natural position. From their undisturbed and perfect condition I am led to conclude that they lived and vegetated on the spot where they are now found. Had they been transported by currents of water, the leaves and branches would have been more confused and broken."

Reference: Section B observations on the Bituminous coal deposits of the valley of the Ohio, and the accompanying rock strata; with notices of the fossil Organic remains and the relics of Vegetable and Animal bodies, illustrated by a Geological map, by numerous drawings of plants and shells, and by views of interesting scenery; by Dr. S. P. Hildreth, of Marietta, Ohio. The American Journal of Science, Volume XXIX, January, 1836, pages 23 and 24.

Location: Section of rock strata at Indian Run, at a point two miles northwest of Marietta, in south-central Muskingum Township, Washington County. Marietta topographic sheet.

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[4]See Journal for Illustrations.

	Ft.	In.
1. Soil and residual	2	0
2. Sandstone, light colored	10	0
3. Sandstone, light colored, coarse grained, (Hundred)	50	0
4. Shale, bituminous, with thin veins of coal of a few inches near the bottom	20	0
5. Limestone, gray	2	0
6. Sandstone, argillaceous, (Upper Marietta)	50	0
7. Marl, brown, with nodules of red oxide of iron, with plant impressions	6	0
8. Sandstone, slaty, (Lower Marietta)	9	0
9. Marl, brown, slaty, with plant impressions	10	0
10. Top of salt well.		

No. 7 is a brown marl, with nodules of red oxide of iron; many of the nodules and flattened pieces contain, when broken, fine impressions of arborescent ferns. Portions of the trunk, two or three feet in length, and three or four inches in diameter, much flattened, are also found on this branch, and probably from this bed. I have fragments, completely replaced by iron ore, in which the woody fibre is very distinct in its large longitudinal fracture. Figures are given at Nos. 27 and 28 (page 12 of the wood cuts) in iron ore from this place. They are both of the genus Neuropteris, but are probably undescribed species. No. 27 resembles Anomopteris, rather more than Neuropteris.

No. 9 is brown slaty marl, upper part of the bed ash colored, lower part, nearly that of Spanish brown, compact and heavy, filled with casts of a thick leaved plant, generally vertical as if buried in a living state. They are too much broken to give definite outlines of their forms, sufficiently correct for a drawing. The middle portion of the bed abounds with impressions of several species of *Neuroptera*. A figure of one of these species is given on No. 29 (page 12 of the wood cuts). The plant is replaced with yellow ochre, and belongs to the arborescent ferns. The upper or ash colored portion of the bed, for about two or three inches in thickness, is filled with the impressions of an asteroid blossom, arranged in rows, upon a stem, sometimes six or eight in a line, the lower half of one resting on the upper half of another. They are of different sizes, but all equal on the same stem, and generally, each floret contains twenty-four petals or rays. The broad leaf of some arundinaceous plant is sometimes seen impressed amongst them. Figure No. 30 (page 9 of the wood cuts) gives a very correct view of their forms and size.

Conclusions

From the evidence obtained in general field work it is thus apparent that plants were abundant through both the Pennsylvanian and Permian cycles of time. The section, with definite plant fossils, from the Sharon of the Pottsville series to the Jollytown of the Greene, is approximately 1,360 feet in thickness. Without search plant fossils are noted on some twenty-six horizons well distributed throughout the column. Careful inspection over wide field will most certainly produce results on each of the fifty-three coal horizons in the geological scale of Ohio.

ADDITIONS TO THE REVISED CATALOGUE OF OHIO VASCULAR PLANTS. XIII[1]

CLYDE H. JONES,
The Ohio State University

In spite of the efforts of the many conscientious collectors who through the years have attempted to build for us in the State Herbarium a permanent record of Ohio's vegetation, some counties are poorly represented. Carroll County, located just south of the glacial boundary in the rugged plateau section of the state, was an outstanding example. Last summer the Ohio Conservation Laboratory was held at Camp Muskingum on Leesville Lake in that county. Students and staff members of the school collected representative specimens of the vegetation in that area to be deposited in the herbarium at the Laboratory and in the State Herbarium. The work will continue this summer.

Three particularly interesting contributions came to the State Herbarium this year. The first two were collected hundreds of miles outside their usually accepted ranges: *Berchemia scandens* the Rattan-vine and *Carex caroliniana* the Carolina Sedge. The third, *Asplenium trudelli* Trudell's Spleenwort, is a hybrid between *Asplenium montanum* the Mountain Spleenwort and *Asplenium pinnatifidum* the Pinnatifid Spleenwort.

The numerous other valuable specimens and collections which have been received during the year are being preserved and will be identified and reported as rapidly as time and assistance permit. We are indeed happy that the hobby of collecting has not been a war casualty among Ohio amateurs.

6. *Botrychium dissectum* Spreng. Cutleaf Grape-fern. Camp Muskingum, Carroll Co. Adele Konopka.
8. *Osmunda regalis* L. Royal-fern. Camp Muskingum, Carroll Co. Clyde H. Jones.
10. *Osmunda cinnamomea* L. Cinnamon-fern. Camp Muskingum, Carroll Co. Clyde H. Jones.
11. *Polypodium virginianum* L. Virginia Polypody. Camp Muskingum, Carroll Co. Adele Konopka.
22.1. *Asplenium trudelli* Wherry. Trudell's Spleenwort. (*A. pinnatifidum* x *A. montanum*). Fairfield and Pike Co. Floyd Bartley and Leslie Pontius.
32. *Camptosorus rhizophyllus* (L.) Link. Walking-fern. Camp Muskingum, Carroll Co. Arthur R. Harper and Adele Konopka.
38. *Dryopteris marginalis* (L.) Gr. Marginal Shield-fern. Camp Muskingum, Carroll Co. Arthur R. Harper and Adele Konopka.
39. *Dryopteris intermedia* (Muhl.) Gr. American Shield-fern. Camp Muskingum, Carroll Co. Arthur R. Harper.
45. *Cystopteris fragilis* (L.) Bernh. Fragile Bladder-fern. Camp Muskingum, Carroll Co. Adele Konopka.
46. *Woodsia obtusa* (Spreng.) Torr. Blunt-lobed Woodsia. Camp Muskingum, Carroll Co. Clyde H. Jones.
54. *Equisetum praealtum* Raf. Great Scouring-rush. Camp Muskingum, Carroll Co. Adele Konopka.
61. *Equisetum arvense* L. Field Horsetail. Camp Muskingum, Carroll Co. Adele Konopka.
65. *Lycopodium clavatum* L. Common Club-moss. Camp Indianola, Fairfield Co. Gene Rea.
82.1. *Sagittaria longirostra* (Micheli) J. G. Sm. Long-beaked Arrow-head. Hocking Co. Floyd Bartley and Leslie Pontius.
119.1 *Philotria canadensis* (Mx.) Britt. Common Water-weed. Camp Muskingum, Carroll Co. Arthur R. Harper.
122.1. *Sparganium americanum* Nutt. Nuttall's Bur-reed. Hocking Co. Floyd Bartley and Leslie Pontius.

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[1]Papers from the Department of Botany, The Ohio State University, No. 486.

131. *Arisaema dracontium* (L.) Schott. Green-dragon. Camp Muskingum, Carroll Co. Arthur R. Harper.
140. *Scirpus lineatus* Mx. Reddish Bulrush. Malvern, Carroll Co. Clyde H. Jones.
144. *Scirpus polyphyllus* Vahl. Leafy Bulrush. Camp Muskingum, Carroll Co. Arthur R. Harper. Wayne Co. L. S. Hopkins.
146. *Scirpus validus* Vahl. Great Bulrush. Wayne and Ashland Co. L. S. Hopkins. Camp Muskingum, Carroll Co. Arthur R. Harper.
148. *Scirpus americanus* Pers. Chair-maker's Clubrush. Ashland Co. L. S. Hopkins.
156. *Eleocharis quadrangulata* (Mx.) R. & S. Four-angled Spike-rush. Ashland Co. L. S. Hopkins.
162. *Eleocharis palustris* (L.) R. & S. Creeping Spike-rush. Wayne and Ashland Co. L. S. Hopkins.
165. *Eleocharis obtusa* (Willd.) Schultes. Blunt Spike-rush. Summit and Portage Co. L. S. Hopkins.
168. *Cyperus strigosus* L. Straw-colored Cyperus. Camp Muskingum, Carroll Co. Arthur R. Harper.
292. *Carex caroliniana* Schw. Carolina Sedge. Malvern, Carroll Co. Clyde H. Jones.
297. *Carex shortiana* Dew. Short's Sedge. Good Hope Twp., Hocking Co. Floyd Bartley.
323. *Carex lupulina* Muhl. Hop Sedge. Malvern, Carroll Co. Clyde H. Jones.
333.1. *Bromus latiglumis* (Shear). Hitch. Wayne Co. L. S. Hopkins.
334. *Bromus purgans* L. Hairy Brome-grass. Carroll Co. Ralph Kriebel.
338. *Festuca elatior* L. Tall Fescue-grass. Portage Co. L. S. Hopkins.
348. *Panicularia canadensis* (Mx.) Ktz. Rattlesnake Manna-grass. Portage Co. L. S. Hopkins.
350. *Panicularia nervata* (Willd.) Ktz. Nerved Manna-grass. Camp Muskingum, Carroll Co. Arthur R. Harper.
352. *Panicularia pallida* (Torr.) Ktz. Pale Manna-grass. Portage Co. L. S. Hopkins.
357. *Poa debilis* Torr. Weak Spear-grass. Portage Co. L. S. Hopkins.
370. *Eragrostis purshii* Schrad. Pursh's Love-grass. Wayne Co. James F. Machwart.
371. *Eragrostis pilosa* (L.) Beauv. Tufted Love-grass. Wayne Co. L. S. Hopkins.
386. *Trisetum pennsylvanicum* (L.) Beauv. Marsh False-oats. Good Hope Twp., Hocking Co. Floyd Bartley.
393. *Nothoholcus lanatus* (L.) Nash. Velvet-grass. Camp Muskingum, Carroll Co. Arthur R. Harper and Ralph Kriebel.
421. *Muhlenbergia schreberi* Gmel. Spreading Muhlenbergia. Camp Muskingum, Carroll Co. Arthur R. Harper.
424. *Oryzopsis racemosa* (Sm.) Ricker. Black-fruited Mountain-rice. Geauga Co. L. S. Hopkins.
433. *Phalaris arundinacea* L. Reed Canary-grass. Camp Muskingum, Carroll Co. Arthur R. Harper.
439. *Agropyron repens* (L.) Beauv. Couch-grass. Gallia Co. E. Ray Bailey via C. J. Willard.
446. *Elymus canadensis* L. Nodding Wild-rye. Belpre Twp., Washington Co. Otis R. Kiracofe. Wayne and Highland Co. L. S. Hopkins.
464. *Panicum stipitatum* Nash. Long Panic-grass. Trumbull Co. L. S. Hopkins.
469. *Panicum miliaceum* L. Millet Panic-grass. Belmont Co. Emma E. Laughlin.
498. *Panicum boscii* Poir. Bosc's Panic-grass. Camp Muskingum, Carroll Co. Arthur R. Harper.
503. *Echinochloa crus-galli* (L.) Beauv. Common Barnyard-grass. Camp Muskingum, Carroll Co. Arthur R. Harper.
562. *Medeola virginiana* L. Indian Cucumber-root. Camp Muskingum, Carroll Co. Adele Konopka.
571. *Vagnera racemosa* (L.) Mor. Panicled False Solomon's-seal. Camp Muskingum, Carroll Co. Arthur R. Harper.
593. *Juncus effusus* L. Common Rush. Ashland Co. L. S. Hopkins.
600. *Juncus aristulatus* Mx. Small-headed Grass-leaf Rush. Wayne Co. L. S. Hopkins.
660. *Peramium pubescens* (Willd.) MacM. Downy Rattlesnake-plantain. Camp Muskingum, Carroll Co. Adele Konopka.
680. *Asimina triloba* (L.) Dunal. Papaw. Carroll Co. Harold S. Vasbinder.
714. *Hepatica triloba* Chaix. Round-lobed Liver-leaf. Camp Muskingum, Carroll Co. Adele Konopka.
728. *Thalictrum polygamum* Muhl. Tall Meadow-rue. Camp Muskingum, Carroll Co. Adele Konopka.
740. *Benzoin aestivale* (L.) Nees. Spicebush. Camp Muskingum, Carroll Co. Adele Konopka.
777. *Radicula palustris* (L.) Moench. Marsh Yellow-cress. Camp Muskingum, Carroll Co. Arthur R. Harper. Monroe Co. Clyde H. Jones.

857. *Oxalis stricta* L. Upright Wood-sorrel. Camp Muskingum, Carroll Co. Adele Konopka.
882. *Polygala viridescens* L. Purple Milkwort. Camp Muskingum, Carroll Co. Adele Konopka.
885. *Polygala ambigua* Nutt. Loose-spiked Milkwort. Camp Muskingum, Carroll Co. Arthur R. Harper.
931. *Hibiscus trionum* L. Bladder Ketmia. Carroll Co. Harold S. Vasbinder.
932. *Tilia americana* L. American Linden. Camp Muskingum, Carroll Co. Clyde H. Jones.
944. *Hypericum mutilum* L. Small-flowered St. John's-wort. Camp Muskingum, Carroll Co. Arthur R. Harper.
1003. *Alsine longifolia* (Muhl.) Britt. Longleaf Stitchwort. Camp Muskingum, Carroll Co. Adele Konopka.
1015. *Lychnis alba* Mill. White Lychnis. Camp Muskingum, Carroll Co. Adele Konopka.
1018. *Silene stellata* (L.) Ait.f. Starry Campion. Camp Muskingum, Carroll Co. Arthur R. Harper and Adele Konopka.
1035. *Dianthus armeria* L. Deptford Pink. Camp Muskingum, Carroll Co. Arthur R. Harper and Adele Konopka.
1040. *Portulaca oleracea* L. Purslane. Camp Muskingum, Carroll Co. Arthur R. Harper.
1044. *Allionia nyctaginea* Mx. Heart-leaf Umbrella-wort. Scioto Co. Conrad Roth.
1083. *Naumburgia thyrsiflora* (L.) Duby. Tufted Yellow Loose-strife. Portage Co. L. S. Hopkins.
1104. *Tiniaria convolvulus* (L.) Webb. & Moq. Black Bindweed. Camp Muskingum, Carroll Co. Adele Konopka.
1108. *Tracaulon sagittatum* (L.) Small. Arrow-leaf Tear-thumb. Camp Muskingum, Carroll Co. Arthur R. Harper and Adele Konopka.
1116. *Persicaria lapathifolia* (L.) S. F. Gr. Pale Persicaria. Camp Muskingum, Carroll Co. Adele Konopka.
1130. *Geum virginianum* L. Rough Avens. Camp Muskingum, Carroll Co. Arthur R. Harper.
1135. *Potentilla monspeliensis* L. Rough Cinquefoil. Camp Muskingum, Carroll Co. Arthur R. Harper.
1164. *Opulaster opulifolius* (L.) Ktz. Ninebark. Camp Muskingum, Carroll Co. Adele Konopka.
1166. *Spiraea tomentosa* L. Steeple-bush. Carroll Co. Clyde H. Jones.
1170. *Rosa setigera* Mx. Prairie Rose. Camp Muskingum, Carroll Co. Arthur R. Harper and Adele Konopka.
1187. *Prunus nana* DuRoi. Choke Cherry. Camp Muskingum, Carroll Co. Arthur R. Harper.
1237. *Chamaecrista nictitans* (L.) Moench. Small-flowered Sensitive-pea. Tuscarawas Co. Earl Jones via C. J. Willard.
1300. *Vicia cracca* L. Cow Vetch. Camp Muskingum, Carroll Co. Adele Konopka.
1321.1. *Pueraris thunbergiana* (Sieb. & Zucc.) Benth. Kudzu. Introduced. Hamilton Co. Eleanor Knoechel.
1348. *Parsonsia petiolata* (L.) Rusby. Blue Waxweed. Camp Muskingum, Carroll Co. Harold S. Vasbinder.
1351.1. *Berchemia scandens* (Hill) Trelease. Rattan-vine. Cranberry Island, Buckeye Lake, Licking Co. L. E. Hicks via Floyd Bartley.
1355. *Rhamnus lanceolata* Pursh. Lance-leaf Buckthorn. Camp Muskingum, Carroll Co. Clyde H. Jones.
1362. *Vitis bicolor* LeC. Winter Grape. Camp Muskingum, Carroll Co. Arthur R. Harper.
1367. *Euonymus atropurpureus* Jacq. Wahoo. Good Hope Twp., Hocking Co. Richard T. Wareham and John N. Wolfe. Carroll Co. Harold S. Vasbinder.
1385. *Acer rubrum* L. Red Maple. Camp Muskingum, Carroll Co. Adele Konopka.
1395. *Hamamelis virginiana* L. Witch-hazel. Camp Muskingum, Carroll Co. Adele Konopka.
1417. *Fagus grandifolia* Ehrh. American Beech. Camp Muskingum, Carroll Co. Adele Konopka.
1422. *Quercus bicolor* Willd. Swamp White Oak. Camp Muskingum, Carroll Co. Clyde H. Jones.
1425. *Quercus macrocarpa* Mx. Bur Oak. Carroll Co. Harold S. Vasbinder.
1431. *Quercus coccinea* Wang. Scarlet Oak. Camp Muskingum, Carroll Co. Clyde H. Jones.
1432. *Quercus borealis* Michx. var. *maxima* (Marsh.) Ashe. Red Oak. Camp Muskingum, Carroll Co. Adele Konopka.
1435. *Ostrya virginiana* (Mill.) Willd. Hop-hornbeam. Camp Muskingum, Carroll Co. Adele Konopka.
1453. *Juglans cinerea* L. Butternut. Camp Muskingum, Carroll Co. Adele Konopka.
1461. *Populus deltoides* Marsh. Cottonwood. Camp Muskingum, Carroll Co. Clyde H. Jones.
1465. *Salix nigra* Marsh. Black Willow. Belpre Twp., Washington Co. Otis R. Kiracofe.

1472. *Salix interior* Row. Sandbar Willow. Belpre Twp., Washington Co. Otis R. Kiracofe.
1535. *Aristolochia serpentaria* L. Virginia Snakeroot. Camp Muskingum, Carroll Co. Clyde H. Jones.
1551. *Pyrola elliptica* Nutt. Shinleaf Wintergreen. Camp Muskingum, Carroll Co. Adele Konopka.
1568. *Diospyros virginiana* L. Persimmon. Carroll Co. Harold S. Vasbinder.
1580. *Phlox stolonifera* Sims. Creeping Phlox. Fairfield Co. John N. Wolfe.
1606.1. *Heliotropium indicum* L. Indian Heliotrope. Introduced. Scioto Co. Conrad Roth.
1621. *Sabbatia angularis* (L.) Pursh. Square-stemmed Sabbatia. Camp Muskingum, Carroll Co. Arthur R. Harper.
1637. *Apocynum medium* Greene. Intermediate Dogbane. Camp Muskingum, Carroll Co. Arthur R. Harper.
1638. *Apocynum cannabinum* L. Indian Hemp. Camp Muskingum, Carroll Co. Arthur R. Harper and Adele Konopka.
1646. *Asclepias incarnata* L. Swamp Milkweed. Camp Muskingum, Carroll Co. Adele Konopka.
1653. *Asclepias quadrifolia* Jacq. Fourleaf Milkweed. Camp Muskingum, Carroll Co. Clyde H. Jones.
1682. *Verbascum blattaria* L. Moth Mullen. Camp Muskingum, Carroll Co. Adele Konopka.
1698. *Mimulus alatus* Soland. Sharp-winged Monkey-flower. Camp Muskingum, Carroll Co. Clyde H. Jones.
1701. *Gratiola neglecta* Torr. Clammy Hedge-hyssop. Camp Muskingum, Carroll Co. Arthur R. Harper.
1717. *Veronicastrum virginicum* (L.) Farw. Culver's-root. Camp Muskingum, Carroll Co. Arthur R. Harper and Clyde H. Jones.
1721. *Veronica americana* Schwein. American Speedwell. Camp Muskingum, Carroll Co. Arthur R. Harper and Clyde H. Jones.
1738. *Linaria linaria* (L.) Karst. Yellow Toadflax. Camp Muskingum, Carroll Co. Arthur R. Harper.
1767. *Lappula virginiana* (L.) Greene. Virginia Stickseed. Camp Muskingum, Carroll Co. Clyde H. Jones.
1788. *Verbena hastata* L. Blue Vervain. Camp Muskingum, Carroll Co. Arthur R. Harper and Adele Konopka.
1798. *Teucrium canadense* L. American Germander. Camp Muskingum, Carroll Co. Clyde H. Jones.
1821. *Lycopus americanus* Muhl. Cutleaf Water-hoarhound. Camp Muskingum, Carroll Co. Arthur R. Harper.
1826. *Collinsonia canadensis* L. Stone-root. Camp Muskingum, Carroll Co. Harold S. Vasbinder.
1829. *Koellia pilosa* (Nutt.) Britt. Hairy Mountain-mint. Camp Muskingum, Carroll Co. Arthur R. Harper and Adele Konopka.
1842. *Agastache nepetoides* (L.) Ktz. Catnip Giant-hyssop. Carroll Co. Harold S. Vasbinder.
1846. *Glecoma hederacea* L. Ground-ivy. Camp Muskingum, Carroll Co. Adele Konopka.
1867. *Monarda fistulosa* L. Wild Bergamot. Camp Muskingum, Carroll Co. Clyde H. Jones.
1868. *Monarda mollis* L. Canescent Wild Bergamot. Camp Muskingum, Carroll Co. Arthur R. Harper.
1880. *Plantago aristata* Mx. Large-bracted Plantain. Malvern, Carroll Co. Arthur R. Harper.
1899. *Daucus carota* L. Wild Carrot. Camp Muskingum, Carroll Co. Adele Konopka.
1902. *Deringa canadensis* (L.) Ktz. Honewort. Camp Muskingum, Carroll Co. Clyde H. Jones.
1936. *Cornus amomum* Mill. Silky Dogwood. Camp Muskingum, Carroll Co. Adele Konopka.
1943. *Nyssa sylvatica* Marsh. Sour Gum or Tupelo. Camp Muskingum, Carroll Co. Adele Konopka.
1952. *Mitchella repens* L. Partridge-berry. Camp Muskingum, Carroll Co. Adele Konopka.
1964. *Galium asprellum* Mx. Rough Bedstraw. Camp Muskingum, Carroll Co. Arthur R. Harper.
2009. *Campanula americana* L. Tall Bellflower. Camp Muskingum, Carroll Co. Arthur R. Harper and Clyde H. Jones.
2014. *Specularia perfoliata* (L.) A.DC. Venus'-looking-glass. Camp Muskingum, Carroll Co. Adele Konopka.
2019. *Lobelia inflata* L. Indian Tobacco. Camp Muskingum, Carroll Co. Arthur R. Harper and Adele Konopka.
2072. *Bidens, laevis* (L.) B. S. P. Smooth Bur-marigold. Camp Muskingum, Carroll Co. Harold S. Vasbinder.
2120. *Solidago bicolor* L. White Goldenrod. Carroll Co. Harold S. Vasbinder.

2132. *Solidago rugosa* Mill. Wrinkled-leaf Goldenrod. Good Hope Twp., Hocking Co. Richard T. Wareham and John N. Wolfe.
2137. *Solidago juncea* Ait. Plume Goldenrod. Camp Muskingum, Carroll Co. Arthur R. Harper and Harold S. Vasbinder.
2141. *Euthamia graminifolia* (L.) Nutt. Bushy Fragrant Goldenrod. Camp Muskingum, Carroll Co. Arthur R. Harper and Harold S. Vasbinder.
2145. *Sericocarpus asteroides* (L.) B. S. P. Toothed White-top Aster. Camp Muskingum, Carroll Co. Arthur R. Harper.
2158. *Aster puniceus* L. Purple-stem Aster. Carroll Co. Harold S. Vasbinder.
2163. *Aster prenanthoides* Muhl. Crooked-stem Aster. Carroll Co. Harold S. Vasbinder.
2170. *Aster multiflorus* Ait. Dense-flowered Aster. Good Hope Twp., Hocking Co. Richard T. Wareham and John N. Wolfe.
2176. *Aster ericoides* L. White Heath Aster. Carroll Co. Harold S. Vasbinder.
2194. *Eupatorium urticaefolium* Reich. White Snake-root. Camp Muskingum, Carroll Co. Arthur R. Harper and Harold S. Vasbinder.
2235. *Synosma suaveolens* (L.) Raf. Sweet-scented Indian-plantain. Athens Co. Walter P. Porter and P. S. Wamsley.
2237. *Mesadenia atriplicifolia* (L.) Raf. Pale Indian-plantain. Camp Muskingum, Carroll Co. Adele Konopka.
2250. *Cirsium odoratum* (Muhl.) Britt. Fragrant Thistle. Camp Muskingum, Carroll Co. Arthur R. Harper.
2252. *Cirsium arvense* (L.) Scop. Canada Thistle. Camp Muskingum, Carroll Co. Arthur R. Harper.
2262. *Chichorium intybus* L. Chicory. Camp Muskingum, Carroll Co. Adele Konopka.
2265. *Krigia virginica* (L.) Willd. Virginia Dwarf-dandelion. Nettle Lake, Williams Co. Floyd Bartley and Leslie Pontius.
2281. *Hieracium aurantiacum* L. Orange Hawkweed. Camp Muskingum, Carroll Co. Adele Konopka.
2282. *Hieracium pratensis* Tausch. Field Hawkweed. Camp Muskingum, Carroll Co. Adele Konopka.
2292. *Nabalus altissimus* (L.) Hook. Tall Rattlesnake-root. Carroll Co. Harold S. Vasbinder.
2295.1. *Iva ciliata* Willd. Rough Marsh Elder. Sells Lake, Athens Co. Walter P. Porter and P. S. Wamsley.
2299. *Sonchus asper* (L.) Hill. Spiny Sow-thistle. Camp Muskingum, Carroll Co. Arthur R. Harper and Adele Konopka.

A SYSTEMATIC STUDY OF THE MAIN ARTERIES IN THE REGION OF HEART—AVES XV.

GAVIIFORMES—PART 1[1]

FRED H. GLENNY[2]

As in other recent studies on the main arteries in the neck and thorax of birds, the writer herein presents the basic arrangement-pattern with such variations as were observed in two species of North American Loons. The present paper is limited to these two forms due to the lack of other species of birds in this Order. This limitation is in part due to the present world conditions. Although the writer had previously planned to discuss a larger number of species in each subsequent paper, it was finally decided that it might be well to present such information as has already been obtained, and such other observations as may be made at a later time would be presented in subsequent papers on this subject. As a result, adequate comparisons between these two species and other species of this order, as well as comparisons between different families of this order, cannot be drawn at the present time.

MATERIALS

Two specimens of each of the two species studied were dissected and diagrams of the arrangement-patterns of the arteries of the neck and thorax prepared. Specimens were made available for this work by the Royal Ontario Museum of Zoology, Toronto, Canada.

Common Loon, *Gavia immer* Linné.

Red-throated Loon, *Gavia stellata* (Pontoppiden).

OBSERVATIONS

As in other birds, the right systemic (4th aortic) arch (3) alone remains as the functional arch of the aorta. The innominate arteries (2) arise from the common aortic root (1), and pass anteriorly to the left and right before dividing to form the common carotid (8) and subclavian (9) arteries.

The subclavian artery gives rise to the coracoid major (10), axillary (13), intercostal (14), and two pectoral (15) arteries in order. The sternotracheal artery (11) arises as a branch of the coracoid major artery. The coracoid minor artery (12) arises from the ventral face of the subclavian artery—opposite the axillary artery—in *Gavia immer*, and from the axillary artery in *Gavia stellata*. The ductus shawi (16) arises from the common carotid artery (8) and sends off branches to the oesophagus, bronchi, and connective tissues in the region of the heart; to the syrinx and trachea (17) and to the oesophagus above the furcula (18). In *Gavia stellata*, an accessory ascending oesophageal artery (23) arises from the left common carotid artery near its point of bifurcation; an accessory meso-oesophageal artery (24) arises from the right common carotid artery; the thyroid arteries arise from these accessory oesophageal arteries (23 and 24). In *Gavia immer*, the thyroid arteries arise variously from the common carotids or one of their branches, chiefly in the region of the ductus shawi.

The common carotid arteries divide to form the superficial cervical arteries (20) and the internal carotid (trunk) arteries (22). Shortly after its origin from the common carotid, the superficial cervical artery gives rise to the scapular artery (19). The right superficial cervical artery serves as the ascending oesophageal artery in the adult bird. The vertebral arteries (21) arise from the internal carotid (trunk) arteries just after the origin of the superficial cervicals.

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[2]Formerly Assistant, Department of Zoology, University of Toronto, Toronto, Canada; now in active service with the United States Army.

Posteriorly, the ligamentous vestige of the left radix aortae—the ligamentum aortae (5)—and the right ligamentum botalli (6) persist. The ligamentum aortae (5) maintains its connection between the left pulmonary arch (7) and the distal portion of the right radix aortae (4), while the ligamentum botalli maintains its proximal attachment with the right pulmonary artery and its distal connection with the right radix aortae.

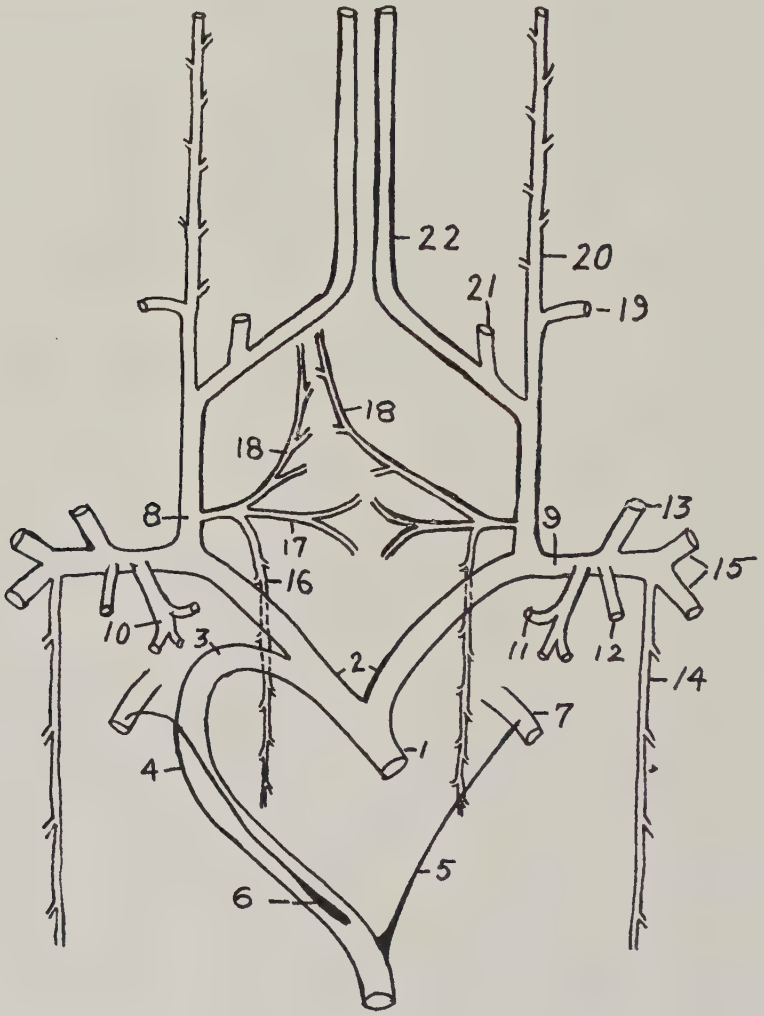

FIG. 1. Diagrammatic representation of the main arteries in the neck and thorax of *Gavia immer*. Ventral view.

KEY TO FIGURES

1. Aortic root; 2. Innominate arteries; 3. Right systemic (4th aortic) arch; 4. Right radix aortae; 5. Left ligamentum aortae; 6. Right ligamentum botalli; 7. pulmonary artery (pulmonary or 6th aortic arch); 8. Common carotid artery; 9. Subclavian artery; 10. Coracoid major artery; 11. Sternotracheal artery; 12. Coracoid minor artery; 13. Axillary artery; 14. Intercostal artery; 15. Pectoral arteries; 16. Ductus shawi; 17. Syringo-tracheal artery; 18. Meso-oesophageal artery; 19. Scapular artery; 20. Superficial cervical arteries (serves as the ascending oesophageal artery on the right side); 21. Vertebral artery; 22. Internal carotid (trunk) arteries; 23. Accessory ascending oesophageal artery; 24. Accessory meso-oesophageal artery; 25. Thyroid arteries.

CONCLUSIONS

In basic arrangement-pattern, the main arteries of the neck and thorax of these two species of Loons are alike. Only minor differences in origin or arrangement of accessory oesophageal arteries are to be noted. Whether or not these minor differences are of any value cannot be evaluated at the present time.

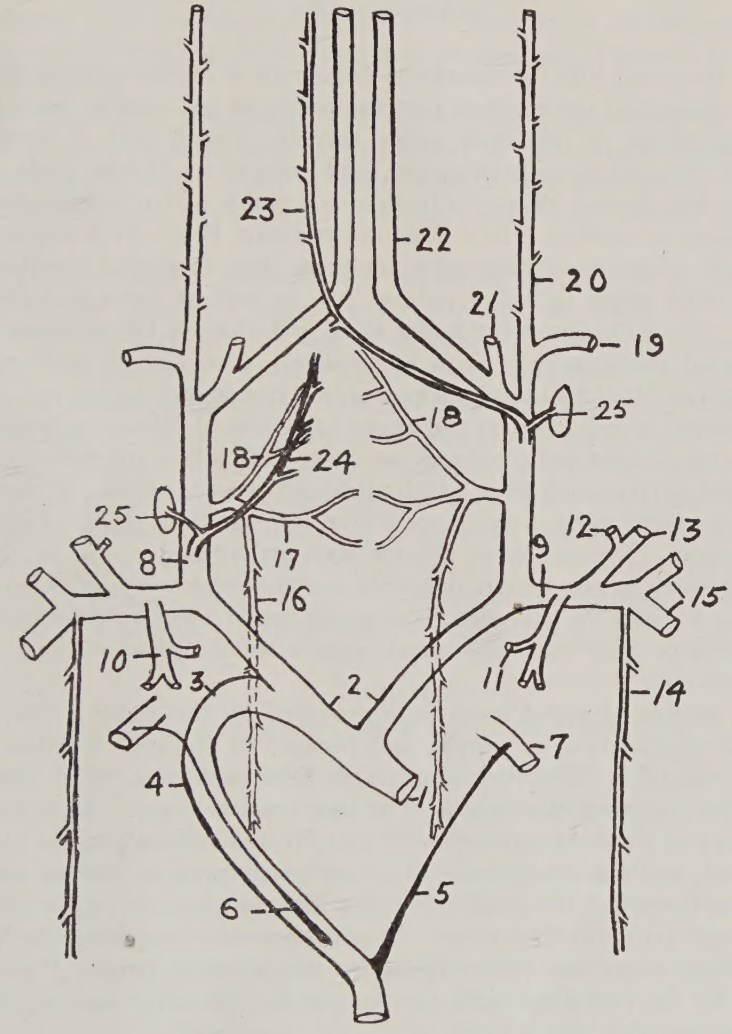

FIG. 2. Diagrammatic representation of the main arteries in the neck and thorax of *Gavia stellata*. Ventral view.

Origin of the coracoid minor artery in the two species may later prove to be of some minor significance. If this group of birds is in a "fluid" state of evolution—or in a state of "flux"—these differences may become increasingly more significant.

ACKNOWLEDGMENTS

The writer wishes to express his appreciation for the assistance given him, in this series of studies, by the staff of the Royal Ontario Museum of Zoology, and to Dr. E. Horne Craigie, Department of Zoology, University of Toronto, for his many helpful suggestions in the course of these studies.

A SERIES OF FIVE MULTIPLE ALLELES[1]

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In 1937 Boye and Rife (1) reported a single pair of alleles as being responsible for a solid purple leaf color versus pattern (brown or red area in central portion of upper epidermis of otherwise green leaves). Purple (P) is dominant to pattern (p). The difference between the solid green of the Golden Bedder variety and pattern was likewise shown to be due to a single pair of alleles, solid green being dominant to pattern. In a later investigation Boye (2) found a series of three multiple alleles to be responsible for these three leaf color variations; solid purple (P), solid green (p^G) and pattern (p), as well as for a new phenotype, gray (Pp^G). Boye (3) also found a new allele (p^S) which in the homozygous state results in solid green leaves. It is incompletely dominant to pattern, in the heterozygous condition resulting in a new phenotype, known as spotted. (Numerous small brown or red spots on the upper epidermis of otherwise green leaves.) The various phenotypes and genotypes involving these alleles are shown in Table I.

This paper is concerned with a fifth allele of the same series. A plant which at first was thought to be of genotype PP or Pp, was later observed to differ in certain respects. The leaf color became such an intense purple as to appear black. The entire calyxes were dark purple, and the petals were dark blue. (Plants of genotypes PP and Pp have light blue petals and green calyxes with red bases.) The purple calyx color was maintained, even after the plant reached maturity and was dried out.

A large number of selfed seeds were produced by this plant. The resulting seedlings all appeared to be purple, and because of cramped facilities most of them were discarded. The remaining plants later proved to be of three types, the differences becoming more apparent as they became larger. Some showed the characteristics of plants of genotypes PP and Pp, some developed the black color of the parent, and the others were of a new phenotype, an uneven purple leaf color. Upon flowering, the petals were of a dark purple color, while the calyxes were green with purple at their bases. These observations suggested the likelihood that the parent plant was heterozygous for two kinds of purple, P and a gene responsible for the new phenotype, uneven purple. We shall use the symbol P^L to designate this allele.

Presumably the plants showing uneven purple leaves were homozygous, of genotype P^LP^L. One of them was crossed with a gray plant ($P\ p^G$) and produced 9 offspring with black leaves, and 6 with non-uniform, gray leaves. The blacks were assumed to be of genotype P^LP, and the non-uniform grays of genotype

[1]Genetic Studies of Coleus. No. V.

[2]Genetics Laboratory, Department of Zoology and Entomology.

P^L p^G. Both the black and the uneven gray plants were crossed with pattern. (Tables II and III.) Offspring of black x pattern (P^LP x pp) occurred in approximately equal numbers of typical purple (Pp) and uneven purple (P^Lp). Offspring of uneven gray x pattern Pp^G x pp) likewise occurred in approximately equal numbers of solid green (p^Gp) and light, uneven purple (Pp^L). The fact that only two phentypes were produced from each of these back crosses confirms the hypothesis that a new allele (P^L), rather than another pair of factors, is responsible for these variations.

A black plant (P^LP) was crossed with a green one of genotype p^Gp. As shown in Table IV, four kinds of offspring were produced, in approximately equal numbers. The leaves of plants of genotype P^Lp^G differ from those of genotype Pp^G principally in the distribution of anthocyanin, it being much more uneven in plants of genotype P^Lp^G.

When selfed, plants of genotype Pp^G produced offspring in the approximate ratio of 1 uneven purple; 2 uneven gray; 1 green (see Table V). A plant of genotype P^LP was crossed with one of genotype p^Sp^S, but no differences were noted among the offspring. All had brown leaves, like plants of genotype Pp^S.

All plants possessing the gene P^L produce dark blue flowers, and a dark purple color at the base of the calyx. No other alleles in this series produce this effect, except the combination Pp^S. The gene P produces red at the base of the calyx, while the genes p^S, p^G and p produce solid green calyxes. The genes p^S, p^G and p produce light blue petals. In respect to calyx color, red (P) is dominant to solid green (p^S, p^G and p), while purple (P^L) is dominant to both red and solid green. In respect to petal color, dark blue (P^L) is dominant to light blue. The genotypic combinations P^LP and Pp^S produce copigmentation effects.

TABLE I

Genotypes and phenotypes of the purple allelic series

Genotype	*Leaf color*	*Calyx color*	*Petal color*
P^LP^L	Uneven purple	Purple at base	Dark blue
P^LP	Black	Solid purple	" "
P^Lp^S	Brown	Purple at base	" "
P^Lp^G	Uneven gray	" " "	" "
P^Lp	" purple	" " "	" "
P P	Even purple	Red at base	Light "
P p^S	Brown	Purple at base	Dark "
P p^G	Even gray	Red at base	Light blue
P p	Even purple	" " "	" "
p^Sp^G	Solid green	Solid green	" "
p^Sp^S	" "	" "	" "
p^Gp^G	" "	" "	" "
p^Gp	" "	" "	" "
p^Sp	Spotted	" "	" "
p p	Pattern	" "	" "

TABLE II

$P^LP \times pp$

Offspring

	Observed	*Calculated*	
P^Lp	69	71	df = 1
			x^2 = 0.112
Pp	73	71	p = 0.7 —0.95

TABLE III

$P^Lp^G \times pp$

Offspring

	Observed	*Calculated*	
P^Lp	67	69.5	df = 1
			x^2 = 0.179
P^Gp	72	69.5	p = 0.5 — 0.7

TABLE IV

$P^LP \times p^Gp$

Offspring

	Observed	*Calculated*	
P^Lp^G	34	33.2	df = 3
Pp^G	35	33.2	x^2 = 0.745
P^Lp	29	33.2	p =0.7 — 0.95
p p	35	33.2	

TABLE V

P^Lp^G selfed

	Observed	*Calculated*	
P^LP^L	14	14.5	df = 2
P^Lp^G	30	29	x^2 = .054
p^Gp^G	14	14.5	p = .95 — .99

SUMMARY

A new allele, which we have designated as P^L, has been discovered in the purple series. This gene produces dark blue petals, dark purple at the base of the calyx, and a more uneven distribution of anthocyanin in the leaves than does its allele P.

LITERATURE CITED

(1) **Boye, C. L.** and **D. C. Rife.** Genetic Studies of Coleus. Jour. Hered. 29: 55–60. 1938.
(2) **Boye, C. L.** An Allelic Series in Coleus. Jour. Genet. XLII: 191–196. 1941.
(3) **Boye, C. L.** Unpublished Doctor's dissertation, Ohio State University. 1941.